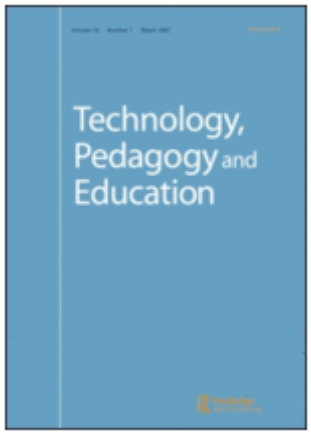

Ready, set, go! Profiling teachers' readiness for online teaching in secondary education

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Ready, set, go! Profiling teachers' readiness for online teaching in secondary education

In a very short time, secondary school education across the globe transitioned to online learning and teaching, in response to the COVID-19 pandemic. This study aims at identifying teacher profiles in secondary education to better understand perceptions of both individual and institutional readiness to transition to online teaching. To do this, the current study grouped teachers on the basis of their TPACK self-efficacy beliefs, online presence and perceived institutional support for online teaching. To date, data has been collected from teachers ($N = 222$) from 20 countries. The data was submitted to latent profile analysis to identify readiness profiles. The added value of the current study lies in the combined view of individual and institutional readiness and the uniqueness of the dataset. It provides a large-scale international perspective and a wide range of possible experiences. Findings inform how education institutions can personalize and support transitions to online teaching.

Keywords: K-12 education; online teaching; TPACK; online presence; teacher readiness; institutional readiness; COVID-19

Introduction

Online teaching and learning have been commonly used for almost two decades in higher education (Martin, Budhrani, & Wang, 2019). The various tools and platforms available to support online interactions, such as discussions, assessment, sharing and interaction have been well developed, tested and have reached a relatively high level of acceptance. However, adoption in school education has been slower. With students and teachers all co-located teaching has been able to happen face-to-face. Research suggests that where online learning has been implemented (aside from distance education), it is actually blended learning where only a portion of the learning is online and in the student's control (Pulham & Graham, 2018).

However, in the first half of 2020, schools across the world were forced to shift to fully online teaching and learning in response to the COVID-19 pandemic. In many instances, this was a sudden shift in delivery of learning. School teachers, many of whom had never taught online, were expected to redesign their programs to support their students in a 100% online environment. This required a full shift in pedagogical approach to teaching and learning, and the use of a range of new technologies (e.g. Gurley, 2018).

In the following discussion, we aim to explore teachers' perceived readiness to shift their teaching from face-to-face to fully online in response to the COVID-19 pandemic. Readiness is examined in relation to perceptions of how well they felt they were prepared for this change and how well they felt their institutions were prepared. Research has shown that both individual and institutional factors influence teachers' capacity to take up new digital practices (e.g. Ertmer & Ottenbreit-Leftwich, 2010; Author/s, 2019). Therefore, we argue that it is necessary to consider teachers' perceptions of both their own readiness and that of their institution, to gain a full view of their position. This combined approach can provide a clearer picture of what support may be needed, either in terms of training or school agenda setting, to support the transition to online teaching.

To do this, we present an international questionnaire designed to capture teachers' general teaching characteristics and experience, self-efficacy teaching online, fostering online presence and institutional support transitioning to online teaching as a result of COVID-19. Latent profile analysis was conducted to identify teacher profiles of readiness to transition to online learning. Profiles provide a way to consider a range of heterogeneous experiences in a given situation (Asendorpf, 2015), from which a more effective person-centred approach to support can be designed. Implications for

practice, school leadership supporting change and future online teaching and learning will be explored through the results.

What is online learning?

The term *online learning* is often used interchangeably with distinct and overlapping terms such as distance learning, blended learning and e-learning. Over the past three decades, online learning has become a significant part of education, internationally (Singh & Thurman, 2019). It is necessary to understand expectations of online learning, to understand the practice of online teaching (i.e. the design and deliver of learning online). However, what comprises online learning and how to develop it to support online learning continues to be a vague area of education and educational research.

One reason for this issue is our understanding of 'What is *online learning*?' Singh and Thurman (2019) identified 46 different definitions of online learning, which mostly come from the higher education context. There are a few commonly agreed elements in online learning, they are often interpreted differently and they have changed over time, as digital technologies supporting online learning have developed. Common elements identified were: Technology, Time, Distance, Interactivity and Educational context (Singh & Thurman, 2019). Interestingly, definitions of online learning did not include *learning* as a concept. A lack of a clear definition in the field limits the possibility of clear articulation in teaching, identification of exemplars and guidance on how to address design (Singh & Thurman, 2019). Therefore, schools adopting online learning are left with limited guidance about how teachers can be supported or what may be an appropriate vision for online learning.

Transition to online teaching

On 30 January, the Covid-19 virus was declared a Public Health Emergency by the World Health Organization (WHO). On 11 March 2020, the WHO declared COVID-19 as a global pandemic (Cucinotta & Vanelli, 2020). On 13 March countries began to implement *lockdowns*, which meant shutting down parts of the economy (Hirsch, 2020). In many places, people were ordered to stay home or at least limit activity outside the home. This included stopping travel, public gatherings and many businesses from trading. It also included moving many forms of work and education into the home. For schools and universities this initiated a rapid transition to fully online teaching and learning occurred around the globe. Suddenly, teachers had to provide fully online teaching, which created an alien situation for themselves and their students (Ferdig et al., 2020). At the time of writing, in many places face-to-face teaching had resumed in schools, but how long schools would stay open is uncertain.

The transition to online teaching for secondary teachers and students was sudden and chaotic. Given that online learning has not been not clearly defined (e.g. Singh & Thurman, 2019) and it is highly variable (Chigeza & Halbert, 2014). In part, the lack of clarity resulted in limited evidence of good practice available to guide the transition. Further, in many cases teachers do not possess knowledge about online pedagogies or how to support learning online, as it is not included in many teacher training programs (McAllister & Graham, 2016). Therefore, many school teachers have limited knowledge of and experience with online learning and teaching.

Areas of teacher knowledge needing development may include knowing which digital online technologies to use and which types of tasks should be included in online learning (e.g., asynchronous discussion tasks, online research tasks, video lectures or live video discussions). In regard to online teaching, questions may include how to be provide clear instruction, how to most effectively communicate and how to most

effectively assess learning (Gurley, 2018). Therefore, to be able to learn from teachers' experiences in the rapid transition to online teaching during the COVID-19 pandemic, it is necessary to investigate how prepared teachers felt they were for online teaching and to understand how they experienced the rapid transition to online learning, so schools can draw on these experiences to prepare for future online and blended learning.

Readiness to teach online

Teaching online requires technological skills, but also different pedagogical approaches than teaching face-to-face, to support learning online (Gurley, 2018). However, the question is to what extent teachers in secondary schooling are prepared to teach online. We argue that readiness to teach online should include considerations across both individual teachers and their institutions. Several studies have explored teacher readiness characteristics that can be associated with the implementation of online teaching and learning (for an overview see Phan & Dang, 2017). However, these studies have focused only on individual educator characteristics and higher education (e.g., Martin, Budhrani, & Wang, 2019).

Individual characteristics affecting online teaching

TPACK self-efficacy

Online teaching self-efficacy can be considered a key component of educators' readiness to teach online (Hung, 2016). Teachers' self-efficacy to teach and support learning has been explored through the lens of the Technological Pedagogical and Content Knowledge (TPACK) framework (Koehler, Mishra, Kereluik, Shin, & Graham, 2014). TPACK comprises several knowledge domains, including domain-general and technology-specific aspects, that are relevant for teachers to implement technology in

teaching and learning processes (Author/s, 2013). Use of the TPACK framework can provide a focus on learning and pedagogy, that is typically missing from conceptions of online learning.

The following dimensions are key to the framework (Author/s, 2018b): TPCK—"knowledge about the complex relations among technology, pedagogy, and content that enable teachers to develop appropriate and context-specific teaching strategies" (Koehler, et al., 2014, p. 102); TPK—knowledge about the use of ICT to implement instructional practices, principles, and strategies; TCK—knowledge about how the subject matter can be represented with the help of technology; TK—knowledge of and about technology. TPCK, TPK, and TCK represent the key pedagogical and didactical aspects of TPACK, while TK represents a purely technological domain (Schmidt et al., 2009). This distinction was evidenced empirically by studies showing that the factor structure of TPACK self-efficacy scales was composed of a general TPACK factor and a specific TK factor (Author/s, 2018b; Author/s, 2017).

Archambault and Crippen (2009) argue that the concept of TPACK is particularly relevant in the context of online learning. According to these authors, the focus becomes more centered around how the online course is designed, with special emphasis on the online teaching materials. At the same time, some studies show a lack of integration between teachers' pedagogical and technological knowledge in the context of online teaching (e.g., Benson & Ward, 2013; Brinkley-Etzkorn, 2018). To illustrate, Benson and Ward (2013) created profiles based on the professor's degree of Technological, Pedagogical and Content knowledge in online higher education. They conclude that the knowledge domains interact in unique patterns and that a balanced

integration of TPACK is unlikely when instructors are not able to verbalize their pedagogical reasoning behind their decisions to teach online. Also, Brinkley-Etzkorn (2018) found that integrating technology and pedagogy is difficult when training new online educators. Therefore, understanding teachers' TPACK self-efficacy can be a useful approach to identifying readiness to teach online.

Online teaching presence

As stated earlier, teaching in an online space differs from face-to-face teaching, because of the separation from students by distance and time (Gurley, 2018). In online teaching, depth of learning in the an online space is related to presence. These can be conceptualized as social, cognitive, and teaching presence (Law, Geng & Li, 2019; Wilson & Stacey, 2004). Online teacher presence emphasizes educators' responsibilities of design, organization, facilitation, and instruction in the online learning space so that educational purposes can be fulfilled while learners and teachers are not co-located or working at the same time (Martin, Budhrani, & Wang, 2019). This is in line with the definition of Arbaugh and Hwang (2006), stating that teaching presence refers to "the design, facilitation, and direction of cognitive social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes" (p. 10). Key components of teaching presence are active communication, providing feedback, and learner-learner interaction (Wilson & Stacey, 2004). Gurley (2018) explored the components of teacher presence in relation to teachers' behaviours in blended and online learning environments. Behaviours related to Feedback, Clear instruction and Assessment were found to relate to teachers' perceptions of high teaching presence.

Institutional support

The rapid transition to online learning, which occurred in schools all around the world in response to the COVID-19 pandemic, pushed fast consideration of how teachers were trained to teach online (if it was possible in the timeframe), if schools had a pedagogical vision about online teaching and learning, how to support students to learn online, etc. Studies show that the success of online teaching can also be affected by institutional characteristics, such as technical support, pedagogical support, or the school vision about the implementation of online or/and blended learning (see Almpanis, 2015; Bao, 2020). While institutional support is crucial for the successful implementation of online education, some studies suggest that it is often insufficient (e.g., Palloff & Pratt, 2013). The level of institutional support largely affects how online courses learning can be implemented and sustained (see e.g., McGee et al., 2017), but it remains unclear whether or not schools actually meet the needs of the teachers to support online learning.

Perceptions of institutional support, particularly values and beliefs of the institution, also serve an important role in change processes (e.g., Ertmer & Ottenbreit-Leftwich, 2010). School leadership, and even leadership in a subject area, can strongly affect how a teacher perceives and values educational and technological-change (Hargreaves & Goodson, 2006). Importantly, strong leadership and clear support to integrate new technologies and practices in teaching and learning can motivate teachers to change, while a lack of commitment to change at an organizational level can demotivate teachers and limit change (Author/s, 2019). To support online learning, several aspects of institutional support, including the schools' vision and professional development for online teaching need to be addressed. In this respect, Author/s (2019b) found that it was not enough to provide training programs to prepare educators to teach online, institutions also need a clear vision and goals related to online teaching and

learning. Teachers' perceptions of institutional support and related goals and vision in view of online education will have an impact on their overall conception of readiness and ability to teach online (e.g. Author/s, 2018). Therefore, to fully understand teachers' perceptions of readiness to engage in technology-related change initiative, it is necessary to examine both individual readiness and beliefs about the readiness of their institution.

Purpose of the study

The main aim of the current study is to identify teacher profiles in secondary education based on their perceptions of readiness to transition to online teaching as a result of COVID-19, in regard to their own readiness and that of their institution. Importantly, teachers' individual and institutional perceptions of readiness are considered together, given that both are influential in teacher change and adoption of new practices related to digital technologies. The research question address is:

1. What are teachers' profiles of readiness to teach online?

To address this question, the current study examines whether teachers can be grouped on the basis of their TPACK self-efficacy beliefs, their online presence and institutional support for online learning. A latent profile analysis was conducted, which represents a person-centred approach (Asendorpf, 2015). While the variable-centered approach is concerned with information about the trait, its structure, stability, and validity for an average person (Bergman & Wångby, 2014), the person-centred approach is considered more holistic in which the persons are regarded dynamic systems of interwoven components (Magnusson, 1988). As each person is considered a functioning totality in the person-centered approach (Bergman & Wångby, 2014), it is often studied by analysing typical patterns, for instance shared by a group/subsample, and not separate variables. Hence, in this study we conduct latent profile analysis to

make visible different groups of teachers, better understand their profiles, and consequently be better prepared to develop and provide adequate training for online teaching and learning.

Materials and methods

In the current study we define *online teaching* and *learning* as: delivering learning content, materials and creating experiences using online platforms or tools, e.g. learning management system, for 80% or more of a subject (Rogers, Berg, Boettcher, Howard, Justice & Schenk, 2009)). This is a technology-focused definition and clearly focusing on delivery in the online space. The definition does not prioritize particular online learning practices related to time or interaction. To be inclusive of a range of educational contexts, it does not emphasize distance as a requisite.

Sample and Procedure

Between March and May 2020, we launched an online survey via Google Forms® that was aimed at assessing educators' readiness for online teaching around the world in response to the COVID-19 pandemic ("So, we're all online?: Readiness for online learning"). The questionnaire was distributed via several social media channels, institutions for higher and continuing education. Participants were fully informed about the intentions of the research before providing tacit consent (by clicking through to the questionnaire) for their data to be included in the study. All data were de-identified before analysis. As of 31 May 2020, the data set comprised 1144 educators in 64 countries, across primary, secondary and higher education. For the current analysis, only those identifying as secondary school teachers were included (n = 222; 68.8 % women) and represented 20 countries. On average, teachers were 43.5 years old (SD =

10.7, range: 23-74) and had 15.3 years of teaching experience (*SD* = 10.1, range: 1-42) across a broad range of subjects (i.e., Arts & Humanities, Social Sciences, Science, Business).

The teachers reported an average of 4.5 years of experience with online teaching in total, but only 34.5 % indicated that they taught online prior to the COVID-19 pandemic. The shift to online teaching was mandatory for 68.1 % of the teachers, and it was expected but not mandatory for 24.4 % of the teachers, and for 7.5 % of the teachers the shift was neither mandatory nor expected. Similarly, most teachers indicated that they had to transfer all their teaching to an online mode (67.6 %), while some indicated that only some (27.9 %) or none of their teaching (4.5 %) went online. On average, teachers were given 4.3 days to prepare for the shift to online teaching and learning. Please find more details about the sample characteristics in the Supplementary Material S1.

Measures

In the present study, we measured teachers' readiness for online teaching by three key components: TPACK self-efficacy (supporting learning), perceived online teaching presence (time and distance), and perceived institutional support (educational context) using scales and standalone items.

Teachers' background variables.

To characterize and explain the profiles, we assessed the following variables: teachers' age (in years), gender (*0 = Male*, *1 = Female*), teaching experience (in years), online teaching before the COVID-19 pandemic (*0 = No prior experience*, *1 = Yes, teachers had prior experience*), days to prepare for online teaching after the decision for

the shift (in days), days into online teaching after the shift (in days), degree of the shift to online teaching (*0 = No, none of it*, *1 = Some of my teaching*, *2 = Yes, all of it.*), degree of the institutional decision to shift to online teaching (*0 = It was mandatory*, *1 = It was expected*, *2 = It was mandatory*).

TPACK self-efficacy.

We focused on the three dimensions TPCK, TPK, and TCK to represent the pedagogical and content-related aspects of online teaching readiness. To assess these dimensions, we administered the validated TPACK self-efficacy scale presented by Archambault and Crippen (2009), which was adapted to the online teaching context. The respective stimulus, "I am confident in my ability to…", introduced two TCK items (e.g., "...implement curriculum in an online environment."), four TPK items (e.g., "...implement different methods of teaching online."), and four TPCK items (e.g., "...use technology to predict students' skills/understanding of a particular topic."). Participants responded on a 5-point agreement scale ranging from 0 (*strongly disagree*) to 4 (*strongly agree*). The internal consistencies of the overall scale were high, Cronbach's Alpha = 0.93, McDonald's Omega = 0.95.

Perceived online teaching presence.

We assessed teachers' perceptions of their online presence through three key dimensions (Gurley, 2018): online teaching presence for clear instruction (POPCLA; e.g., "Overall, I can clearly communicate important course goals"; 4 items), student feedback and assessment (POPFED; e.g., "Overall, I provide feedback in a timely fashion"; 4 items), and cognitive activation (POPCOG; e.g., "Overall, I help to keep course participants on a task in a way that helps students to learn"; 5 items). Teachers indicated their agreement with these statements on a 5-point scale ranging from 0

(*strongly disagree*) to 4 (*strongly agree*). The resultant three subscales showed sufficiently high internal consistencies (POCLA: $\alpha = 0.90$, $\omega_t = 0.92$; POPFED: $\alpha = 0.82$, $\omega_t = 0.87$; POPCOG: $\alpha = 0.90$, $\omega_t = 0.93$).

Perceived institutional support.

We assessed teachers' perceptions of the institutional support for online teaching using six items of the scale proposed by Philipsen (2018). These items addressed several aspects of institutional support, including the schools' vision and professional development for online teaching (e.g., "In my institution, there is a supportive environment as regards professional development for online learning", "In my institution, there are clear objectives as regards online learning"). Participants indicated their agreement with the six items on a 6-point scale ranging from 0 (*strongly disagree*) to 5 (*strongly agree*), and the internal consistency was high, Cronbach's Alpha = 0.95, McDonald's Omega = 0.96. Given that this scale addressed the general institutional support independent of the COVID-19 pandemic, we further added two standalone items that assessed teachers' perceptions of the technical and pedagogical support specific to the transition to online teaching during the COVID-19 pandemic (Stimulus: "If your institution has asked you to transition your teaching from face-to-face to online, have you been provided with the following..."; item PISCO1: "Additional technical support has been provided to transition face-to-face teaching to online because of COVID-19"; item PISCO2: "Additional pedagogical support has been provided to transition face-to-face teaching to online because of COVID-19").

Statistical Analyses

Confirmatory Factor Analysis.

To identify unobserved (latent) profiles of teachers with respect to their readiness for online teaching, we first examined the psychometric quality of the scales measuring their TPACK self-efficacy, perceived online presence, and institutional support. Specifically, we evaluated their factor structures conducting confirmatory factor analysis (Brown, 2015). For all scales, we specified a single-factor model as a baseline model, modified it following our hypotheses on the specific structure of the scale (e.g., assuming multiple factors instead of a single factor), and evaluated the model fit utilizing goodness-of-fit indices (for an acceptable fit: CFI≥.95, RMSEA≤.08, SRMR≤.10; e.g., Hu & Bentler, 1999). Once we had identified a well-fitting factor model, we extracted the respective factor scores and used them as observed (manifest) representatives of the scale. To accommodate possible deviations from the assumption of multivariate normality for the items within a scale, we used robust maximum-likelihood (MLR) estimation and derived robust standard errors of all model parameters. Consequently, model comparisons were based on the Satorra-Bentler adjusted chi-square (SB-) difference test (Satorra & Bentler, 2010). We performed all analyses in the R packages 'lavaan' version 0.6-6 (Rosseel, 2012) and 'psych' version 1.9.12.31 (Revelle, 2019), utilizing the full-information-maximum-likelihood procedure to handle missing item responses (Enders, 2010). Please find all details of these analyses in the Supplementary Material S1.

Latent Profile Analysis (LPA)

As a second step, we performed latent profile analysis using the factor scores of TPACK self-efficacy (gTPACK), the three dimensions of perceived online presence

(POPCLA, POPFED, POPCOG), perceived institutional support (gPIS), and the two standalone items asking teachers about the perceived support for online teaching during the COVID-19 pandemic (PISCO1 and PISCO2). LPA represents a person-centered approach that identifies homogeneous groups in a sample based on a set of profile indicators (Lubke & Muthén, 2005) and offers a more flexible and model-based approach to identifying groups than cluster analysis (Marsh, Lüdtke, Trautwein, & Morin, 2009). Furthermore, LPA offers relative fit indices, such as the Akaike information criterion [AIC], the Bayesian information criterion [BIC], and the sample-size-adjusted BIC [aBIC], allowing researchers to compare different assumptions on the number of profiles, their shape, and sizes.

Typically, identifying the number of latent profiles in a sample follows a rigorous procedure in which a series of LPAs are conducted with varying numbers of profiles (Masyn, 2013). The resultant models are then compared via the adjusted Lo-Mendell-Rubin [LMR] and the Vuong-Lo-Mendell-Rubin [VLMR] likelihood-ratio tests [LRT], information criteria, and the entropies, that is, an indicator of classification accuracy with acceptable values above .70 (Jung & Wickrama, 2008). However, the optimal profile solution should reveal conceptually meaningful and interpretable profiles of substantial size (Marsh et al., 2009). We performed the LPA with the software package M*plus* version 8.3 (Muthén & Muthén, 1998-2017), using MLR estimation. Please find the details in the Supplementary Material S2.

Results

Descriptive Statistics, Measurement Models, and Correlations

The descriptive statistics for the variables we submitted to LPA (i.e., the profile indicators) did not indicate any ceiling or floor effects, and the respective items only marginally deviated from an optimal normal distribution (see Supplementary Material S1). Table 1 exhibits the respective statistics and the correlation matrix.

<Insert Table 1 here>

Profile indicators were positively and significantly correlated, with high correlations among indicators representing the subscales of the same construct and low to moderate correlations among indicators of different constructs. The full item-level correlation matrix is presented in Supplementary Material S3.

Next, we inspected the measurement models of the scales (see Supplementary Material S1). The model describing *TPACK self-efficacy* contained a general TPACK factor and four residual covariances among items that addressed the same concepts or similar formulations, SB-$\chi^2(31) = 43.8$, $p = .064$, CFI = 0.988, RMSEA = 0.043, SRMR = 0.031. Neither a single-factor model without residual covariances nor a model distinguishing between TPCK, TPK, and TCK as three correlated factors exhibited good fit to the data. The latter showed factor correlations between $\rho = 0.95$ and $\rho = 0.98$. *Perceived institutional support* was represented by a single factor and a residual covariance between two item. The respective model showed excellent fit to the data, SB-$\chi^2(8) = 11.4$, $p = .179$, CFI = 0.996, RMSEA = 0.044, SRMR = 0.015. Finally, the measurement model distinguishing between three factors of *perceived online teaching presence* (i.e., POPCLA, POPFED, POPCOG) exhibited a good fit to the data (SB-χ^2 [60] $= 84.4$, $p = .021$, CFI = 0.981, RMSEA = 0.043, SRMR = 0.034) and resulted in

factor correlations between $\rho = 0.68$ and $\rho = 0.84$. Two residual covariances were part of this model (see Supplementary Material S1).

Latent Profile Analysis

Identifying the number of profiles.

Table 2 shows the resultant log-likelihood values, the information criteria, entropies, and the likelihood-ratio tests comparing the model with *k* profiles to the model with *k*-1 profiles.

<Insert Table 2 here>

Increasing the number of profiles decreased the log-likelihood values and information criteria and indicated a better fit of the LPA models with more profiles. At the same time, the likelihood-ratio tests suggested that this decrease was no longer statistically significant when adding one more profile to the three-profile solution—however, the extant literature discusses these tests controversially, especially because they only test global model fit differences and may not have sufficient power to detect the correct number of profile in situations with a highly separability of the profiles (Tein, Coxe, & Cham, 2013). In this sense, these tests should not serve as the only source for determining the profiles. Examining the information criteria, we also found an elbow in their decrease between three and four profiles. Finally, the entropy was the highest for the five-profile model. We further examined the profile sizes and their shapes and found that very small and hardly distinguishable profiles occurred for more than four profiles (see Table 2). Although the three-profile model exhibited well-interpretable profiles with consistently low, medium, or high values of the profile

indicators, adding one more profile identified a group of teachers with a pattern that could be clearly distinguished from these three standard profiles. Considering the high entropy (0.924), the preference over the three-profile model according to the information criteria, the sufficiently large profile sizes, and the interpretability of the profiles, we accepted the LPA model with four profiles as the final model.

To further back this decision, we examined whether the four profiles differed significantly in the profile indicators using a multivariate analysis of variance. The overall, multivariate test of mean differences between the four profiles was statistically significant (Pillai's trace V = 0.56, F[7, 212] = 38.7, p < .001) and explained about 57 % of the variance in the profile indicators. Further post-hoc tests revealed significant profile differences in all profile indicators (Fs > 12.99, ps < .001), explaining between 5.6 % (PISCO1) and 50.0 % (POPGEN) of variation. These findings support the distinction between the four profiles.

Considering the heterogeneous nature of the sample, we also tested for possible country effects. To do this, we extended the LPA to multilevel LPA with countries as cluster units and tested for significant between-country variation in the profile membership probabilities. The comparison between the LPA model with predictors at the individual level and its multilevel extension did not reveal any significant variation between countries (Likelihood-ratio test: chi-square[6] = 3.9, p = .69). Hence, we did not have evidence for country effects.

Characterizing the profiles.

The characteristics of teachers in the four profiles are presented in Table 3. The four profiles are presented in Figure 1. It is observed that Profile 3 has the largest

membership with 46.6 % of the sample (n = 103) and the smallest being Profile 4 with 13.5 % (n = 30).

Figure 1 presents the factor means of each profile for teachers' perceptions of their own readiness (gTPACK, POPCLA, POPFED & POPCOG) and readiness of their institution (gPIS, PISCO1 & PISCO2). Strong correlations (see Table 1) between gTPACK and gPIS are reflected in Profiles 2-4, and strong correlations among subfactors of both gTPACK and gPIS are observed in all four profiles. On teachers' perceptions of their individual readiness to teach online, Profiles 3 and 4 both reflect teachers' positive perceptions, resulting in 59.9 % of participants reporting positive perceptions about their readiness to teach online. This is particularly interesting, given the majority of the sample reported having not previously taught online. It can also be noted that teachers in Profile 4 had more days to prepare to teach online (see Table 3).

Profiles 1 and 2 both reflect negative perceptions; variance on all factors was less in Profiles 3 and 4 than Profiles 1 and 2 (see SupplementaryMaterial-S4).

<Insert Table 3 here>

<Insert Figure 1 here>

On teachers' perceptions of their institution's readiness to teach online, the pattern changes slightly. Profiles 1, 3 and 4, comprising 83.3% of the sample, reflect positive perceptions about institutional readiness. Profile 2 is the only group to report negative perceptions of institutional readiness. Results suggest these are strongly negative perceptions across all three institutional factors. Teachers in Profile 1 and 2 had similar perceptions of their individual readiness, but analysis of background variables relating to institutional experiences suggests participants were more likely to be members of Profile 1 (B = -0.40, SE = 0.19, p < .039, OR = 0.67) if the transition to

online teaching in response to COVID-19 was not made mandatory in their institution or if they did not have to transition all of their teaching (see Table 3).

In summary, four profiles were identified. These can be classified as representing 'High' perceptions of readiness' (Profile 4), 'Medium' perceptions (Profile 3), 'Low' perceptions' (Profile 1) and 'Mixed' perceptions (Profile 2). It can be observed that the four-profile solution does indeed provide a theoretically meaningful representation of teachers' perceptions. This also highlights the importance of institutional readiness, particularly for teachers with lower perceptions of their own readiness to teach online. Implications and scenarios will be considered in the next section.

Discussion, implications and future research

The main aim of the current study is to identify teacher profiles in secondary education based on their perceptions of readiness to transition to online teaching as a result of COVID-19, in regard to their own readiness and that of their institution. Addressing the research question, the main contribution of this paper is the identification of four profiles based on combined individual and institutional factors. In the following discussion, we explore the implications of individual and institutional perceptions of each profile in regard to the COVID-19 transition to online teaching and how these findings can inform future change initiatives.

First, we consider implications of Profiles 3 and 4, Medium and High perceptions of readiness for online teaching, respectively. While both of these groups are positive, the nature of their perception are quite different. Primarily, the Medium group is only weakly positive, and significantly lower than the High group. As a result,

the level of support to transition to online teaching between these two sets of teachers would vary significantly. In particular, the Medium group would likely benefit from direct support on how to facilitate learning (gTPACK), create clear instruction (POPCLA), provide feedback (POPFED) and keep students engaged (POPCOG). Given the Medium group has generally expressed positive perceptions, the teachers would likely feel positively about online teaching and learning and be receptive to targeted support to develop their online teaching (Almpanis, 2015; Bao, 2020). Given the very positive perceptions and higher experience with online teaching in the High group. These teachers could be used in a school to support their peers to design and implement online learning.

In terms of institutional support, given the strong correlation between perceptions of Institutional Support (gPIS) and support for the COVID-19 transition (PISCO1 & PISCO2), it is unsurprising that teachers in the Medium group felt their institutions had less overall support for online learning. The transition to online learning was also less likely to be mandatory for teachers in the Medium group (see Table 3). However, it is necessary to consider possible effects of the relationship between their individual perceptions and what they perceive as support at their institution. Teachers in the Medium profile reported their institutions were only weakly supporting them technologically and pedagogically to transition to online learning, this is likely to affect how they perceive their own readiness (e.g. Chandra & Mills, 2015; Ertmer & Ottenbreit-Leftwich, 2010). A perceived lack of support or a weakly positive perception of support in relation to variables, such as professional development, clear objectives and an institutional strategy will affect how teachers approach online learning, what

they feel are the objectives and how they design interactions. For teachers with only weak positive perception of their own readiness, it would actually be more important for institutions to have a strong vision and clear goals for online teaching and learning (Hargreaves & Goodson, 2006; Author/s, 2019). A lack of consistency across an institution will also affect the experiences of their students, which in secondary education may then be highly variable across their different subjects (e.g. McGee et al., 2017). For teachers in the High profile, they reported very positive perceptions of their institutional readiness. However, while not statistically significantly different in the sample, the technological support was higher than pedagogical support. For teachers with more experience in online teaching, ongoing pedagogical support would be important for them to continue professional learning and experimenting with new online learning approaches (e.g. Philipsen et al., 2019). This should be a consideration for high performing teachers in change initiatives. However, during the rapid shift to online teaching during the COVID-19 pandemic, it would be unlikely this group would be engaging in training. They would be able to instead provide necessary 'just-in-time' institutional support for other teachers, and support through communities of practice beyond their schools, to support a consistent vision of online learning and teaching (e.g. Author/s, 2018).

Teachers in the Low and Mixed profiles, Profiles 1 and 2 respectively, reported negative perceptions of their individual readiness to teach online. The difficulty of this, in the rapid transition to online learning in the COVID-19 pandemic, is that there was little time to provide teachers with the necessary professional development. In this case, how institutions approach the rapid transition to support teachers is even more

important than usual. With this in mind, we consider the split between Low and Mixed groups on institutional readiness and implications for institutional responses during the rapid transition..

The Low group also reported very negative perceptions of their institution's readiness, while the Mixed group was positive. First, it is quite possible that the Low group's strong negative perceptions of their institutions affected their perceptions of readiness, their engagement in teaching online and designing online learning (e.g. Hargreaves & Goodson, 2006). Further, the finding that teachers in the Low group were less likely to have a mandatory online transition in their institution, combined with their negative perceptions, suggests they may have experienced a more chaotic approach to the transition to online teaching. In contrast, the Mixed group was actually more positive about their institutional readiness than the Medium group. Positive perceptions of their institution would have a positive effect on their individual readiness (Ertmer & Ottenbreit-Leftwich, 2010). While the Mixed teachers might not have felt confident, they would be more likely to be motivated to teach online if their institutions created a clear vision and provided the necessary support (Author/s., 2018).

Institutional responses at times of rapid changes in teaching and learning could possibly compensate for a lack of time and/or training for teachers to appropriately prepare for changes. For teachers with a Low or Mixed profile, a strong institutional response to change could significantly improve their experience and the experiences of their students. This is particularly important for changes initiatives around online learning, where there is not a clear understanding of what this comprises (Singh & Thurman, 2019) or disciplinary expectations in secondary education. Future research

will explore some of the implications of interactions between individual and institutional readiness. While participating teachers represented 20 different countries in the sample, there was no country effect in profile membership. However, given the small sample size ($N = 222$), the results should be considered exploratory, rather than generalizable. Therefore, teachers' qualitative responses will be analysed to better understand their experience transitioning to online teaching, in relation to the specific factors (e.g. TPACK, online presence and institutional readiness) to gain a better understanding of the profiles, where educational context affects teachers' experiences and what type of support may be appropriate for each group.

A limitation of the study is distribution through social media and other online channels. This potentially exclude teachers who are not active online and would potentially have a different experience in online learning. However, a reasonable way to access international teachers who are/were transitioning to online teaching, but not participating in social media, does not exist. Moreover, while distribution through social media afforded access to teachers across 20 countries, there were only 1-2 teachers from many of those contexts. This limits the ability to test for differences between countries. A second issue is the absence of an outcome variable to understand the implications of profile membership on design of online learning and results of their transition. A significant proportion of teachers have agreed to a follow up study where the results of rapid transition and online teaching, both of these issues will be addressed by further exploring a range of countries and contexts to better understand the online learning and teaching outcomes for each profile.

Conclusions

The rapid transition from face-to-face teaching to online in secondary education, in response to the COVID-19 pandemic, was unprecedented. The short timeframe to transition to online teaching and learning resulted in limited time for teachers to upskill and prepare. Therefore, the role of the institution had an important responsibility to provide support and a common view of expectations for online learning and teaching, to compensate for individual perceptions of readiness. Clearly from the four profiles how this happened across the 20 countries was quite variable. While the immediate transition from face-to-face teaching has passed, and many students and teachers across the world have returned to the classroom, teaching practice in schools will forever be changed. Change is likely to be on-going, given the need to prepare for possible similar events in the future, but also to continue to integrate some of the new and useful practices teachers have learned and adopted in this time. Findings from this study provide important insights into four profiles of readiness that can guide institutions and teachers to support on-going development of online pedagogies, teaching and learning. Importantly, the individual and the institution need to be considered together, to better understand teachers' experiences, their need for support and the need for a clear understanding of online learning and teaching.

References

Almpanis, T. (2015). Staff development and institutional support for technology enhanced learning in UK universities. *The Electronic Journal of E-Learning*, *13*(5), 366-375.

Arbaugh, J. B., & Hwang, A. (2006). Does "teaching presence" exist in online MBA courses?. *The Internet and Higher Education*, *9*(1), 9-21.

Archambault, L., & Crippen, K. (2009). Examining TPACK Among K-12 Online Distance Educators in the United States. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 71-88.

Author/s 2013 Removed for review

Author/s 2017 Removed for review

Author/s 2018 Removed for review

Author/s 2018b Removed for review

Author/s 2019 Remover for review

Author/s 2019b Removed for review

Asendorpf, J. B. (2015). Person-centered approaches to personality. In M. Mikulincer, P. R. Shaver, M. L. Cooper, & R. J. Larsen (Eds.), *APA handbooks in psychology®. APA handbook of personality and social psychology, Vol. 4. Personality processes and individual differences* (p. 403–424). American Psychological Association. https://doi.org/10.1037/14343-018

Bao, W. (2020). COVID-19 and online teaching in higher education: A case study of Peking University. *Human Behavior and Emerging Technologies*, *2*(2), 113-115.

Benson, S. N. K., & Ward, C. L. (2013). Teaching with technology: Using TPACK to understand teaching expertise in online higher education. *Journal of Educational Computing Research*, *48*(2), 153-172.

Bergman, L. R., & Wångby, M. (2014). The person-oriented approach: A short theoretical and practical guide. Estonian Journal of Education, 2(1), 2014, 29–49. doi: http://dx.doi.org/10.12697/eha.2014.2.1.02b

Brinkley-Etzkorn, K. E. (2018). Learning to teach online: Measuring the influence of faculty development training on teaching effectiveness through a TPACK lens. *The Internet and Higher Education*, *38*, 28-35.

Brown, T. A. (2015). Confirmatory Factor Analysis for Applied Research (2nd ed.). New York, NY: The Guilford Press.

Chandra, V., & Mills, K. A. (2015). Transforming the core business of teaching and learning in classrooms through ICT. *Technology, Pedagogy and Education*, *24*(3), 285–301. https://doi.org/10.1080/1475939X.2014.975737

Chigeza, P., & Halbert, K. (2014). Navigating e-learning and blended learning for pre-service teachers: Redesigning for engagement, access and efficiency. Australian Journal of Teacher Education, 39(11), 133–146. doi:10.14221/ajte.204v39n11.8

Cucinotta, D., & Vanelli, M. (2020). WHO Declares COVID-19 a Pandemic. *Acta bio-medica : Atenei Parmensis*, *91*(1), 157–160. https://doi.org/10.23750/abm.v91i1.9397

Enders, C. K. (2010). *Applied missing data analysis*. New York, NY, US: Guilford Press.

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: how knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education*, *42*(3), 255–284. https://doi.org/GALE|A221849729

Hargreaves, A., & Goodson, I. (2006). Educational Change Over Time? The Sustainability and Nonsustainability of Three Decades of Secondary School Change and Continuity. *Educational Administration Quarterly*, *42*(1), 3–41. https://doi.org/10.1177/0013161X05277975

Gurley, L. E. (2018). Educators' Preparation to Teach, Perceived Teaching Presence, and Perceived Teaching Presence Behaviors in Blended and Online Learning Environments. *Online Learning*, 22(2). doi:10.24059/olj.v22i2.1255

Hirsch, C. (2020, March 31). Europe's coronavirus lockdown measures compared. *Politico*. https://www.politico.eu/article/europes-coronavirus-lockdown-measures-compared/

Hu, L. t., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1-55. doi:10.1080/10705519909540118

Hung, M. L. (2016). Teacher readiness for online learning: Scale development and teacher perceptions. Computers & Education, 94, 120-133. https://doi.org/10.1016/j.compedu.2015.11.012

Jung, T., & Wickrama, K. A. S. (2008). An introduction to latent class growth analysis and growth mixture modeling. *Social and Personality Psychology Compass*, *2*(1), 302-317. doi:10.1111/j.1751-9004.2007.00054.x

Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2014). The technological pedagogical content knowledge framework. In *Handbook of research on educational communications and technology* (pp. 101-111). Springer, New York, NY.

Law, K. M., Geng, S., & Li, T. (2019). Student enrollment, motivation and learning performance in a blended learning environment: The mediating effects of social, teaching, and cognitive presence. *Computers & Education*, *136*, 1-12. https://doi.org/10.1016/j.compedu.2019.02.021

Lubke, G. H., & Muthén, B. (2005). Investigating population heterogeneity with factor mixture models. *Psychological Methods*, *10*(1), 21-39. doi:10.1037/1082-989X.10.1.21

McAllister, L. & Graham, C. (2016). An Analysis of the Curriculum Requirements for K-12 Online Teaching Endorsements in the U.S. *Journal of Online Learning Research, 2*(3), 247-282. Waynesville, NC USA: Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/173220/.

Magnusson, D. (1988). *Individual development from an interactional perspective: A longitudinal study*. Hillsdale, NJ, England: Lawrence Erlbaum Associates.

Marsh, H. W., Lüdtke, O., Trautwein, U., & Morin, A. J. S. (2009). Classical Latent Profile Analysis of Academic Self-Concept Dimensions: Synergy of Person- and Variable-Centered Approaches to Theoretical Models of Self-Concept. *Structural Equation Modeling: A Multidisciplinary Journal*, *16*(2), 191-225. doi:10.1080/10705510902751010

Martin, F., Budhrani, K., & Wang, C. (2019). Examining Faculty Perception of Their Readiness to Teach Online. *Online Learning*, *23*(3), 97-119.

Masyn, K. E. (2013). Latent class analysis and finite mixture modeling. In *The Oxford handbook of quantitative methods: Statistical analysis* (Vol. 2, pp. 551-611). New York, NY, US: Oxford University Press.

McGee, P., Windes, D., & Torres, M. (2017). Experienced online instructors: Beliefs and preferred supports regarding online teaching. *Journal of Computing in Higher Education*, *29*, 331-352. doi:10.1007/s12528-017-9140-6.

Muthén, L. K., & Muthén, B. O. (1998-2017). *Mplus User's Guide* (8th ed.). Los Angeles, CA: Muthén & Muthén.

Phan, T. T. N., & Dang, L. T. T. (2017). Teacher Readiness for Online Teaching: A Critical Review. *International Journal Open Distance E-Learn. IJODeL*, *3*(1), 1-16.

Palloff, R. M., & Pratt, K. (2013). *Lessons from the virtual classroom: The realities of online teaching*. John Wiley & Sons.

Philipsen, B. (2018). *Teacher professional development for online and blended learning in adult education and training.* (Doctor in Educational Sciences Doctoral Dissertation). Vrije Universiteit Brussel, Brussels, Belgium.

Pulham, E., & Graham, C. R. (2018). Comparing K-12 online and blended teaching competencies: a literature review. *Distance Education*, *39*(3), 411–432. https://doi.org/10.1080/01587919.2018.1476840

Revelle, W. (2019). psych: Procedures for Psychological, Psychometric, and Personality Research. R package version 1.9.12. Evanston, Illinois: Northwestern University. Retrieved from https://CRAN.R-project.org/package=psych

Rogers, P. L., Berg, G. A., Boettcher, J. V., Howard, C., Justice, L., & Schenk, K. D. (Eds.). (2009). *Encyclopedia of distance learning*. IGI Global.

Rosseel, Y. (2012). lavaan: An R Package for Structural Equation Modeling. *Journal of Statistical Software*, *1*(2). doi:10.18637/jss.v048.i02

Satorra, A., & Bentler, P. M. (2010). Ensuring Positiveness of the Scaled Difference Chi-square Test Statistic. Psychometrika, 75(2), 243-248. doi:10.1007/s11336-009-9135-y

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological Pedagogical Content Knowledge (TPACK). *Journal of Research on Technology in Education*, *42*(2), 123-149. doi:10.1080/15391523.2009.10782544

Singh, V., & Thurman, A. (2019). How Many Ways Can We Define Online Learning? A Systematic Literature Review of Definitions of Online Learning (1988-2018), American Journal of Distance Education, 33:4, 289-306, DOI: 10.1080/08923647.2019.1663082.

Tein, J.-Y., Coxe, S., & Cham, H. (2013). Statistical Power to Detect the Correct Number of Classes in Latent Profile Analysis. Structural Equation Modeling: A Multidisciplinary Journal, 20(4), 640-657. doi:10.1080/10705511.2013.824781

Wilson, G., & Stacey, E. (2004). Online interaction impacts on learning: Teaching the teachers to teach online. Australasian journal of educational technology, 20(1).

Zhang, H., Lin, L., Zhan, Y., & Ren, Y. (2016). The impact of teaching presence on online engagement behaviors. *Journal of Educational Computing Research*, *54*(7), 887-900.

Table 1

Means, standard deviations, and correlations with confidence intervals

Variable	*M*	*SD*	1	2	3	4	5	6
1. gTPACK	0	0.80						
2. gPIS	0	1.18	.36** [.24, .47]					
3. PISCO1	2.60	1.62	.34** [.22, .45]	.71** [.64, .77]				
4. PISCO2	2.08	1.54	.37** [.25, .48]	.72** [.65, .78]	.68** [.60, .74]			
5. POPGEN	0	0.75	.66** [.58, .73]	.35** [.23, .46]	.32** [.19, .43]	.33** [.21, .45]		
6. POPCLA	0	0.65	.62** [.53, .69]	.36** [.24, .47]	.34** [.22, .45]	.28** [.15, .39]	.74** [.68, .80]	
7. POPFED	0	0.68	.65** [.56, .72]	.36** [.24, .47]	.33** [.21, .44]	.33** [.21, .44]	.91** [.88, .93]	.82** [.78, .86]

Table 3

Teacher Characteristics within the Four Profiles

Teacher characteristics	Profile 1 (*n* = 37)	Profile 2 (*n* = 52)	Profile 3 (*n* = 103)	Profile 4 (*n* = 30)
Background variables				
Age *M* (*SD*) in years	41.9 (9.3)	44.9 (11.3)	43.5 (11.2)	42.6 (9.3)
Gender				
Women	21.6 %	36.5 %	33.0 %	27.6 %
Men	78.4 %	63.5 %	67.0 %	72.4 %
Teaching experience *M* (*SD*) in years	14.9 (10.2)	15.5 (11.0)	15.3 (10.3)	15.2 (8.1)
Online teaching and learning				
Prior online teaching experience				
Yes	10.8 %	17.3 %	27.2 %	53.3 %
No	89.2 %	82.7 %	72.8 %	46.7 %
Days of preparation for online teaching *M* (*SD*)	3.6 (4.4)	2.4 (3.7)	3.9 (5.1)	9.5 (27.4)
Shift to online teaching due to COVID-19				
No, none of the teaching was shifted.	2.7 %	9.6 %	2.9 %	3.3 %
Some of the teaching was shifted.	27.0 %	19.2 %	32.0 %	30.0 %
Yes, all of the teaching was shifted.	70.3 %	71.2 %	65.1 %	6.7 %
Days into online teaching after the shift *M* (*SD*)	1.4 (0.7)	1.5 (1.1)	1.8 (1.3)	1.6 (1.5)
Institutional decision of the shift				
It was not mandatory.	13.9 %	6.2 %	6.0 %	6.9 %
It was expected, but not mandatory.	27.8 %	27.1 %	24.0 %	17.2 %
It was mandatory.	58.3 %	66.7 %	70.0 %	75.9 %

Table 2

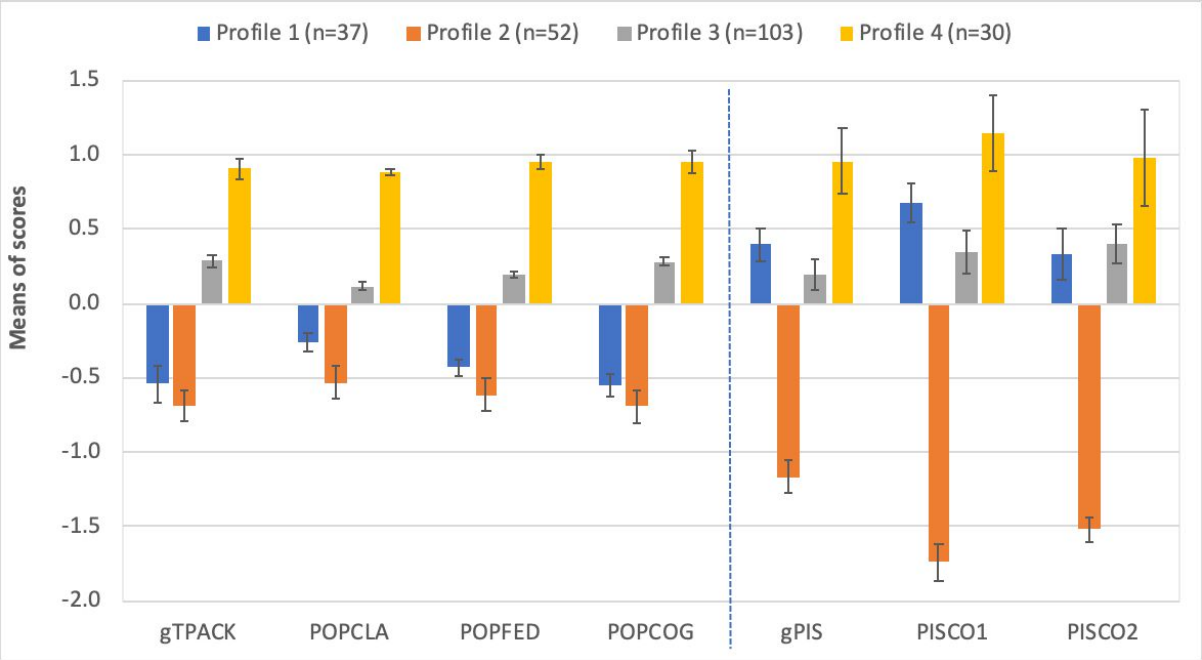
Information criteria, entropies and results of the likelihood-ratio tests for the LPA models with one to six profiles

Model	LL	Npar	SCF	AIC	BIC	aBIC	Entropy	*p*(VLMR-LRT)	*p*(LMR-LRT)	Description
One profile	-2139.006	14	1.0201	4306.012	4353.649	4309.282	1.000	-	-	Baseline model
Two profiles	-1888.273	29	1.1282	3834.547	3933.224	3841.321	0.857	0.3061	0.309	Two profiles with high vs. low scores
Three profiles	-1731.877	44	0.8431	3551.753	3701.471	3562.031	0.921	0.0461	0.0474	Three profiles with high, medium, and low scores
Four profiles	-1642.848	59	0.8146	3403.695	3604.453	3417.477	0.924	0.2398	0.2413	Suggested solution
Five profiles	-1549.075	74	0.9864	3246.150	3497.948	3263.436	0.935	1.0000	1.0000	Smallest group: *n* = 11, two very similar profiles
Six profiles	-1482.811	89	0.8325	3143.622	3446.460	3164.412	0.926	1.0000	1.0000	Smallest group: *n* = 10, three very similar profiles, convergence issues

Note. LL = Log-likelihood value, Npar = Number of parameters, SCF = Scale correction factor, AIC = Akaike's Information Criterion, BIC = Bayesian Information Criterion, aBIC = Sample size-adjusted BIC, *p*(VLMR-LRT) = *p*-value of the Vuong-Lo-Mendell-Rubin (VLMR) likelihood-ratio test, *p*(LMR-LRT) = *p*-value of the Lo-Mendell-Rubin (LMR) likelihood-ratio test. The suggested number of profiles is highlighted in gray.

Figure 1

Profiles describing secondary school teachers' readiness for online teaching



Note. gTPACK = TPACK self-efficacy, POPCLA = Perceived online teaching presence: Clarity of instruction, POPFED = Perceived online teaching presence: Feedback to and assessment of students, POPCOG = Perceived online teaching presence: Cognitive activation, gPIS = Perceived institutional support in general, PISCO1 = Perceived institutional support: Technical support during COVID-19, PISCO2 = Perceived institutional support: Pedagogical support during COVID-19.

Appendix A

TPACK self-efficacy scale

Technological Content Knowledge

(o) My ability to use technological representations (i.e. multimedia, visual demonstrations, etc.) to demonstrate specific concepts in my content area.

(t) My ability to implement district curriculum in an online environment.

(v) My ability to use various courseware programs to deliver instruction (e.g., Blackboard, Centra).

Technological Pedagogical Knowledge

(h) My ability to create an online environment which allows students to build new knowledge and skills.

(l) My ability to implement different methods of teaching online

(n) My ability to moderate online interactivity among students

(p) My ability to encourage online interactivity among students

Technological Pedagogical Content Knowledge

(e) My ability to use online student assessment to modify instruction

(k) My ability to use technology to predict students' skill/understanding of a particular topic

(w) My ability to use technology to create effective representations of content that depart from textbook knowledge

(x) My ability to meet the overall demands of online teaching

Adapted from Archambault and Crippen (2009).

Appendix B

Online teaching presence scale

1. Overall, I clearly communicate important course topics.
2. Overall, I clearly communicate course goals.
3. Overall, I provide clear instructions on how to participate in course learning activities.
4. Overall, I clearly communicate important due dates/time frames for learning activities.
5. Overall, I am helpful in identifying areas of agreement and disagreement on course topics that help students to learn.
6. Overall, I am helpful in guiding the class towards understanding course topics in a way that helps students clarify their thinking.
7. Overall, I help to keep course participants engaged and participating in productive dialogue.
8. Overall, I help keep the course participants on task in a way that helps students learn.
9. Overall, I encourage course participants to explore new concepts in courses.
10. Overall, my actions reinforce the development of a sense of community among course participants.
11. Overall, I help to focus discussion on relevant issues in a way that helps students to learn.
12. Overall, I provide feedback that helps students understand their strengths and weaknesses relative to the course's goals and objectives.
13. Overall, I provide feedback in a timely fashion.

Adapted from Gurley (2018).

Appendix C

Institutional support for online learning

Completely disagree	Disagree	Disagree more than agree	Agree more than disagree	Agree	Completely agree
0	1	2	3	4	5

In our institution …

1. there is a clear vision towards OL.
2. there is a supportive environment as regards professional development for OL.
3. there are clear objectives as regards OL.
4. the current ICT-possibilities and infrastructure as regards OL are taken into account.
5. attention is payed to the teacher change processes inherent to changing to online or blended learning.
6. there is a professional development strategy towards OL.

Adapted from Philipsen (2018).

Ready, set, go! Profiling readiness for online teaching

Supplementary Material S1: Descriptive Statistics, Scales, and Measurement Models

02 July 2020

Contents

Preparation

Install and load relevant R packages

```
# Install R packages (if needed)
# install.packages("lavaan")
# install.packages("semPlot")
# install.packages("psych")
# install.packages("corrplot")
# install.packages("ggplot2")
# install.packages("ggpubr")
# install.packages("ggrepel")
# install.packages("apaTables")
# install.packages("PerformanceAnalytics")
# install.packages("polycor")
# install.packages("tidyLPA")
# install.packages("dplyr")

## Load relevant libraries
library(lavaan)
library(psych)
library(semPlot)
library(corrplot)
library(ggplot2)
library(ggpubr)
library(ggrepel)
library(apaTables)
library(PerformanceAnalytics)
library(polycor)
library(tidyLPA)
library(dplyr)
```

Data input

```
## Read the data
covid19otlc.tpe <- read.csv2("COVID19OTLC-30052020-TPE.csv")
head(covid19otlc.tpe , 5)
```

```
##   COUNTRYID COHORTID PERSONID UNPERSID REGIONID EDUCATION AGE FEMALE TEACHEXP
## 1        36        4       30     4030        2         3  40      0        5
## 2        36        4      312     4312        2         3  64      1       23
## 3        36        4       26     4026        2         3  31      1        7
## 4        36        4       28     4028        2         3  37      1        7
## 5        36        4       32     4032        2         3  37      1        7
##   SUBJECT ONTEACHEXP OTLEXP ONTEACHPER OTLPREP OPLAT OTLSHIFT OTLDAYS INSTDEC
## 1      NA         NA      0         NA       0    NA        2       1       2
## 2      NA          6      1        0.4       0     5        2       1       2
## 3      NA         NA      0         NA       0    NA        2       1       1
## 4      NA         NA      0         NA       0    NA        2       0       2
## 5      NA         NA      0         NA       2    NA        2       1       2
##   TCK1 TCK2 TPK1 TPK2 TPK3 TPK4 TPCK1 TPCK2 TPCK3 TPCK4 POTP1 POTP2 POTP3 POTP4
## 1    2    2    2    2    1    2     2     1     2     1     3     2     2     3
```

```
## 2    4    4    4    4    3    3     3     3     4     2     3     3     3     3
## 3    3    3    3    3    2    3     3     3     3     2     3     3     3     3
## 4    0    0    0    0    1    1     0     0     0     1     3     3     3     3
## 5    3    4    4    3    2    2     2     3     3     3     4     4     4     4
##   POTP5 POTP6 POTP7 POTP8 POTP9 POTP10 POTP11 POTP12 POTP13 PIS1 PIS2 PIS3 PIS4
## 1     2     2     2     2     2      2      2      3      3    2    0    1    2
## 2     3     3     3     3     3      3      3      3      1    2    2    2    1
## 3     3     3     3     3     3      3      3      3      3    3    3    3    3
## 4     2     3     1     1     1      1      1      3      3    3    4    4    4
## 5     3     3     2     2     2      2      3      4      4    2    3    2    3
##   PIS5 PIS6 PISCO1 PISCO2  GII GII21 GII22 GII23 GII31 GII73     SELF     TEAM
## 1    1    0      0      1 50.3    61  50.6  61.4    89  39.5 12.69386 11.19544
## 2    0    0      0      1 50.3    61  50.6  61.4    89  39.5 12.69386 11.19544
## 3    2    3      2      2 50.3    61  50.6  61.4    89  39.5 12.69386 11.19544
## 4    2    4      3      2 50.3    61  50.6  61.4    89  39.5 12.69386 11.19544
## 5    2    2      1      3 50.3    61  50.6  61.4    89  39.5 12.69386 11.19544
##     PORGIN STRATIO  PREPICT PRACICT    PDICT     COOP     WELS PDI IDV MAS UAI
## 1 12.30725 12.9719 1.241755 2.00287 1.473027 9.888961 9.445077  38  90  61  51
## 2 12.30725 12.9719 1.241755 2.00287 1.473027 9.888961 9.445077  38  90  61  51
## 3 12.30725 12.9719 1.241755 2.00287 1.473027 9.888961 9.445077  38  90  61  51
## 4 12.30725 12.9719 1.241755 2.00287 1.473027 9.888961 9.445077  38  90  61  51
## 5 12.30725 12.9719 1.241755 2.00287 1.473027 9.888961 9.445077  38  90  61  51
##   LTO IVR
## 1  21  71
## 2  21  71
## 3  21  71
## 4  21  71
## 5  21  71
```

Descriptive Statistics of Variables

Teacher Background Variables

```
############################################################
## Sample size
nrow(covid19otlc.tpe)
```

```
## [1] 222
```

```
############################################################
## Countries
table(covid19otlc.tpe$COUNTRYID)
```

```
##
##  36  56  76 203 276 300 356 392 422 484 528 554 566 578 620 704 710 792 826 840
##  46 124   1   1   2   1   2   2   1   1   5   1   2  17   3   1   5   1   4   2
```

```
prop.table(table(covid19otlc.tpe$COUNTRYID))
```

```
##
##          36          56          76         203         276         300
## 0.207207207 0.558558559 0.004504505 0.004504505 0.009009009 0.004504505
##         356         392         422         484         528         554
## 0.009009009 0.009009009 0.004504505 0.004504505 0.022522523 0.004504505
```

```
##         566         578         620         704         710         792
## 0.009009009 0.076576577 0.013513514 0.004504505 0.022522523 0.004504505
##         826         840
## 0.018018018 0.009009009
```

```
nrow(table(covid19otlc.tpe$COUNTRYID))
```

```
## [1] 20
```

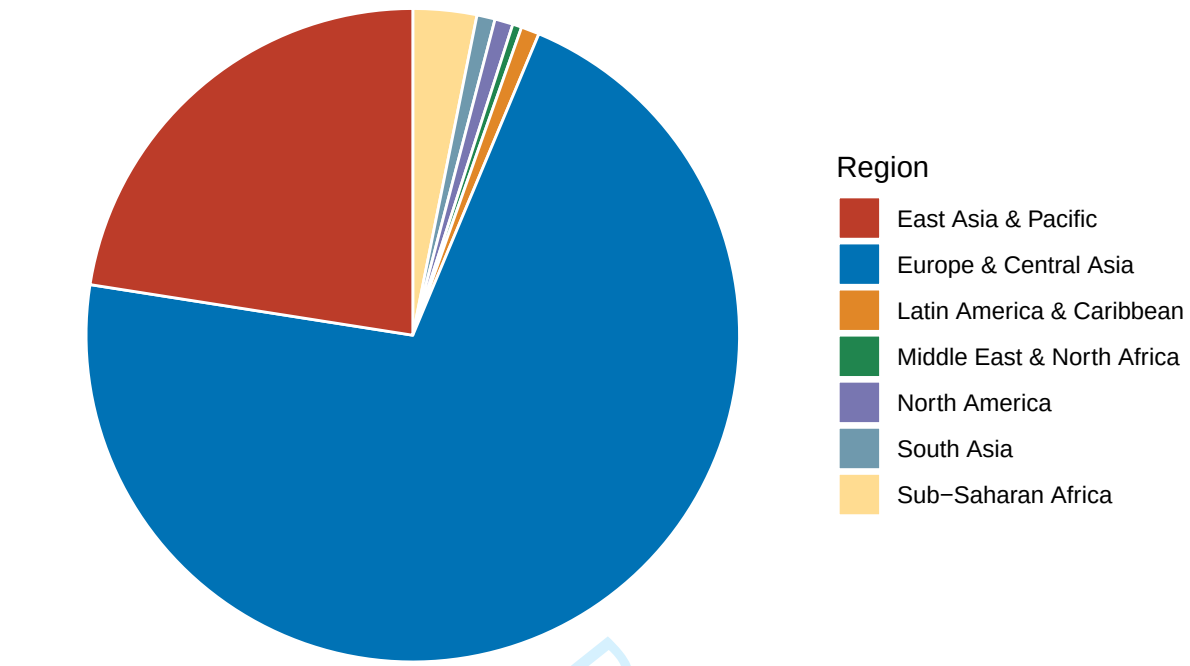
```
############################################################
## Regions
table(covid19otlc.tpe$REGIONID)
```

```
##
##   1   2   3   4   5   6   7
## 158  50   2   1   2   2   7
```

```
prop.table(table(covid19otlc.tpe$REGIONID))
```

```
##
##           1           2           3           4           5           6
## 0.711711712 0.225225225 0.009009009 0.004504505 0.009009009 0.009009009
##           7
## 0.031531532
```

```
## Make the dataframe
rid <- data.frame(c("Europe & Central Asia",
                    "East Asia & Pacific",
                    "Latin America & Caribbean",
                    "Middle East & North Africa",
                    "North America",
                    "South Asia",
                    "Sub-Saharan Africa"),
                  table(covid19otlc.tpe$REGIONID))
colnames(rid) <- c("Region", "REGIONID", "Frequency")

## Pie chart
ggpie(rid, "Frequency",
      label = "Region",
      fill = "Region",
      percent = TRUE,
      color = "white",
      palette = "nejm",
      label.size = 3,
      title = "Distribution of World Regions in the Sample",
      facet.label.size = 11,
      ggtheme = theme_pubr()) +
  theme_void()
```




```
## Add a new variable indicating the region as being in Europe or not
covid19otlc.tpe$EUROPE <- NA
covid19otlc.tpe$EUROPE[covid19otlc.tpe$REGIONID=="1"] <- 1
covid19otlc.tpe$EUROPE[covid19otlc.tpe$REGIONID=="2"] <- 0
covid19otlc.tpe$EUROPE[covid19otlc.tpe$REGIONID=="3"] <- 0
covid19otlc.tpe$EUROPE[covid19otlc.tpe$REGIONID=="4"] <- 0
covid19otlc.tpe$EUROPE[covid19otlc.tpe$REGIONID=="5"] <- 0
covid19otlc.tpe$EUROPE[covid19otlc.tpe$REGIONID=="6"] <- 0
covid19otlc.tpe$EUROPE[covid19otlc.tpe$REGIONID=="7"] <- 0

## Check the data
table(covid19otlc.tpe$EUROPE)
```

```
##
##   0   1
##  64 158
```

```
############################################################
## Age (in years)
summary(covid19otlc.tpe$AGE)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##   23.00   35.00   43.50   43.46   51.00   74.00       2
```

```
table(covid19otlc.tpe$AGE)
```

```
##
## 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
##  1  1  6  3  2  3  7  7  6  6  3  6  6  4  9  4 13  4  4  7  8 11  5  8  5 10
## 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 74
##  8  7 10  2  3  2  1  6  8  2  4  6  2  1  2  3  2  1  1
```

```r
which(is.na(covid19otlc.tpe$AGE))
```

```
## [1] 28 35
```

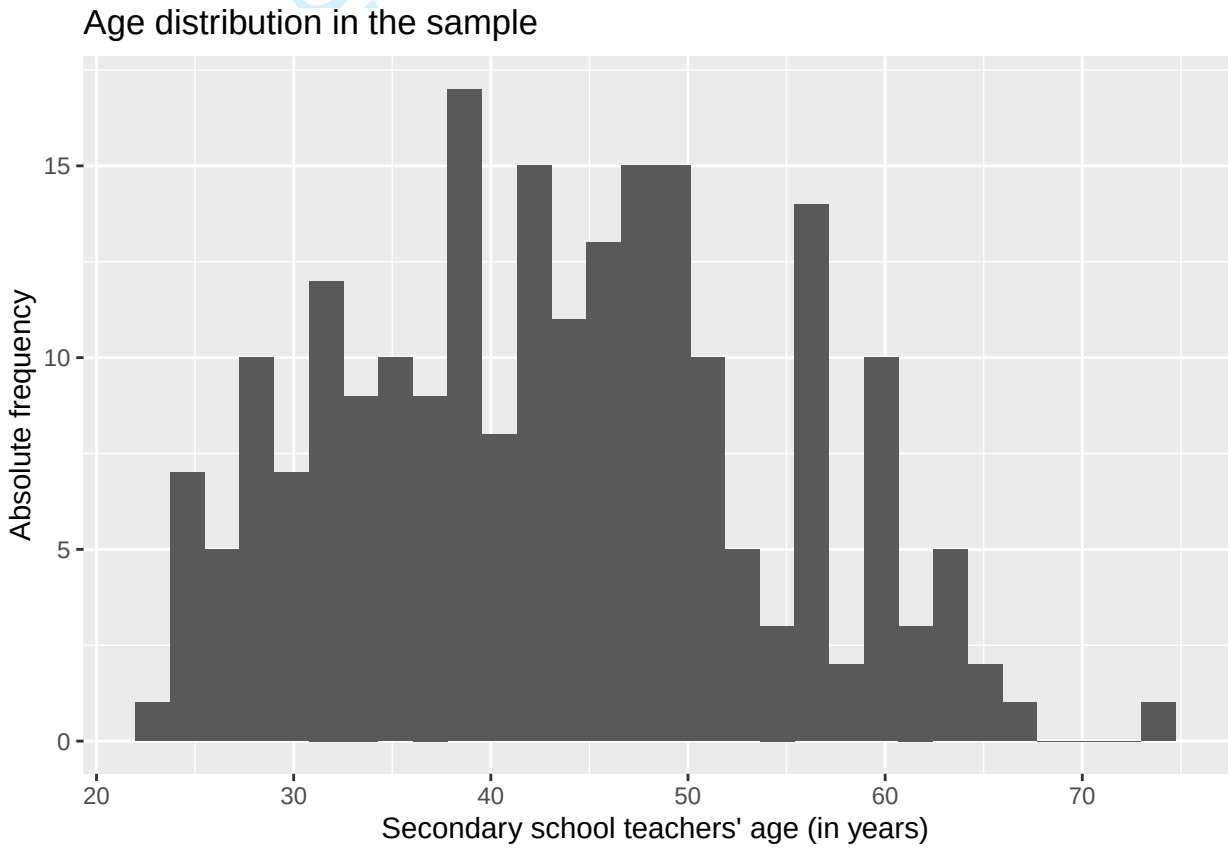
```r
sum(is.na(covid19otlc.tpe$AGE))
```

```
## [1] 2
```

```r
## Histogram
qplot(covid19otlc.tpe$AGE, geom = "histogram",
      main = "Age distribution in the sample",
      xlab = "Secondary school teachers' age (in years)",
      ylab = "Absolute frequency")
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

```
## Warning: Removed 2 rows containing non-finite values (stat_bin).
```



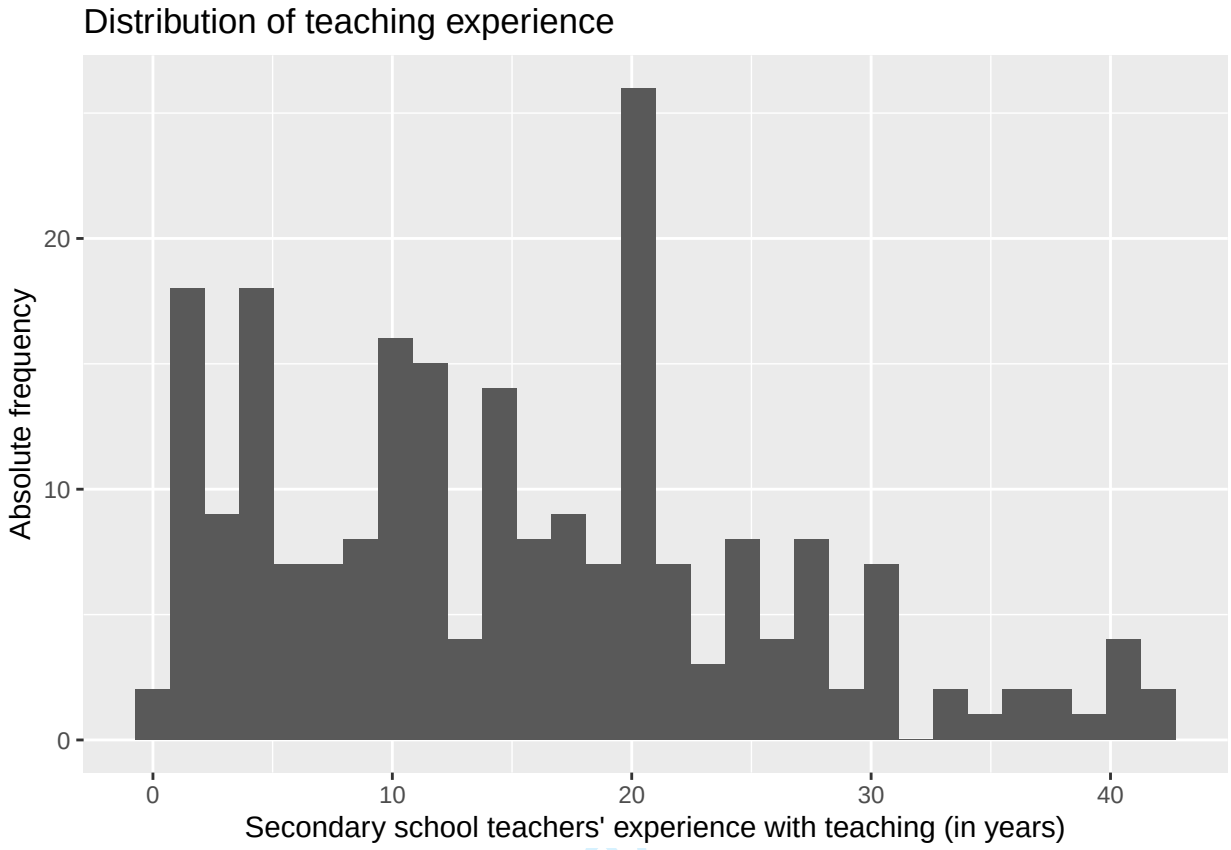

```r
##############################################################
## Gender
table(covid19otlc.tpe$FEMALE)
```

```
##
##   0   1
##  69 152
```

```r
prop.table(table(covid19otlc.tpe$FEMALE))
```

```
##
##         0         1
```

```
## 0.3122172 0.6877828
############################################################
## Teaching experience (in years)
summary(covid19otlc.tpe$TEACHEXP)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##    0.00    7.00   15.00   15.27   21.00   42.00       1
table(covid19otlc.tpe$TEACHEXP)

##
##  0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
##  2 12  6  9  8 10  7  7  4  4 16  7  8  4  5  9  8  3  6  7 18  8  7  3  3  5
## 26 27 28 29 30 31 34 35 36 37 38 39 40 42
##  4  5  3  2  6  1  2  1  2  1  1  1  4  2
which(is.na(covid19otlc.tpe$TEACHEXP))

## [1] 187
sum(is.na(covid19otlc.tpe$TEACHEXP))

## [1] 1
## Histogram
qplot(covid19otlc.tpe$TEACHEXP, geom = "histogram",
      main = "Distribution of teaching experience",
      xlab = "Secondary school teachers' experience with teaching (in years)",
      ylab = "Absolute frequency")

## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## Warning: Removed 1 rows containing non-finite values (stat_bin).
```




```
############################################################
## Main subject domain
summary(covid19otlc.tpe$SUBJECT)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##    1.00    3.00    5.00    4.19    5.00    6.00     201
```

```
table(covid19otlc.tpe$SUBJECT)
```

```
##
##  1  2  3  5  6
##  2  2  3 11  3
```

```
which(is.na(covid19otlc.tpe$SUBJECT))
```

```
##   [1]   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18
##  [19]  19  20  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37
##  [37]  38  39  40  41  42  43  44  45  46  47  49  50  51  52  53  54  55  56
##  [55]  57  58  59  60  61  62  64  65  66  67  68  69  70  71  73  74  75  76
##  [73]  78  80  81  82  83  84  85  86  87  88  90  91  92  93  94  95  96  98
##  [91] 100 101 102 103 104 105 106 108 110 111 112 113 114 115 116 117 118 119
## [109] 120 121 123 124 125 126 127 128 129 130 131 132 133 134 135 138 139 140
## [127] 141 142 143 144 145 147 148 149 150 151 152 153 154 155 157 158 159 160
## [145] 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 178 179
## [163] 180 181 182 183 184 185 186 188 189 190 192 193 194 195 197 198 199 200
## [181] 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218
## [199] 219 221 222
```

```r
sum(is.na(covid19otlc.tpe$SUBJECT))
```

```
## [1] 201
```

```r
## Exclude due to too many missings

############################################################
## Online teaching experience (in years)
summary(covid19otlc.tpe$ONTEACHEXP)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##   0.000   1.000   4.000   4.446   6.000  20.000     166
```

```r
table(covid19otlc.tpe$ONTEACHEXP)
```

```
##
##  0  1  2  3  4  5  6  7  8 10 12 14 15 20
##  4 13  6  4  8  6  4  1  1  5  1  1  1  1
```

```r
which(is.na(covid19otlc.tpe$ONTEACHEXP))
```

```
##   [1]   1   3   4   5   8  11  12  14  15  17  18  22  25  29  31  32  34  35
##  [19]  36  37  40  41  43  49  50  51  54  55  56  59  60  61  62  63  64  65
##  [37]  66  67  68  69  70  72  79  80  81  82  83  84  85  86  87  88  89  90
##  [55]  91  92  93  94  95  96  97  98  99 100 101 102 103 104 105 106 107 108
##  [73] 109 110 111 112 113 114 116 117 118 119 120 121 122 123 124 125 126 127
##  [91] 128 131 132 133 134 135 136 137 138 139 140 141 142 144 145 146 148 149
## [109] 150 151 152 153 154 155 157 158 159 160 162 163 164 165 166 167 169 170
## [127] 173 174 175 176 177 178 179 181 182 183 184 185 187 190 191 192 193 194
## [145] 195 198 199 200 201 202 203 204 205 206 208 209 211 213 214 215 216 217
## [163] 218 219 220 222
```

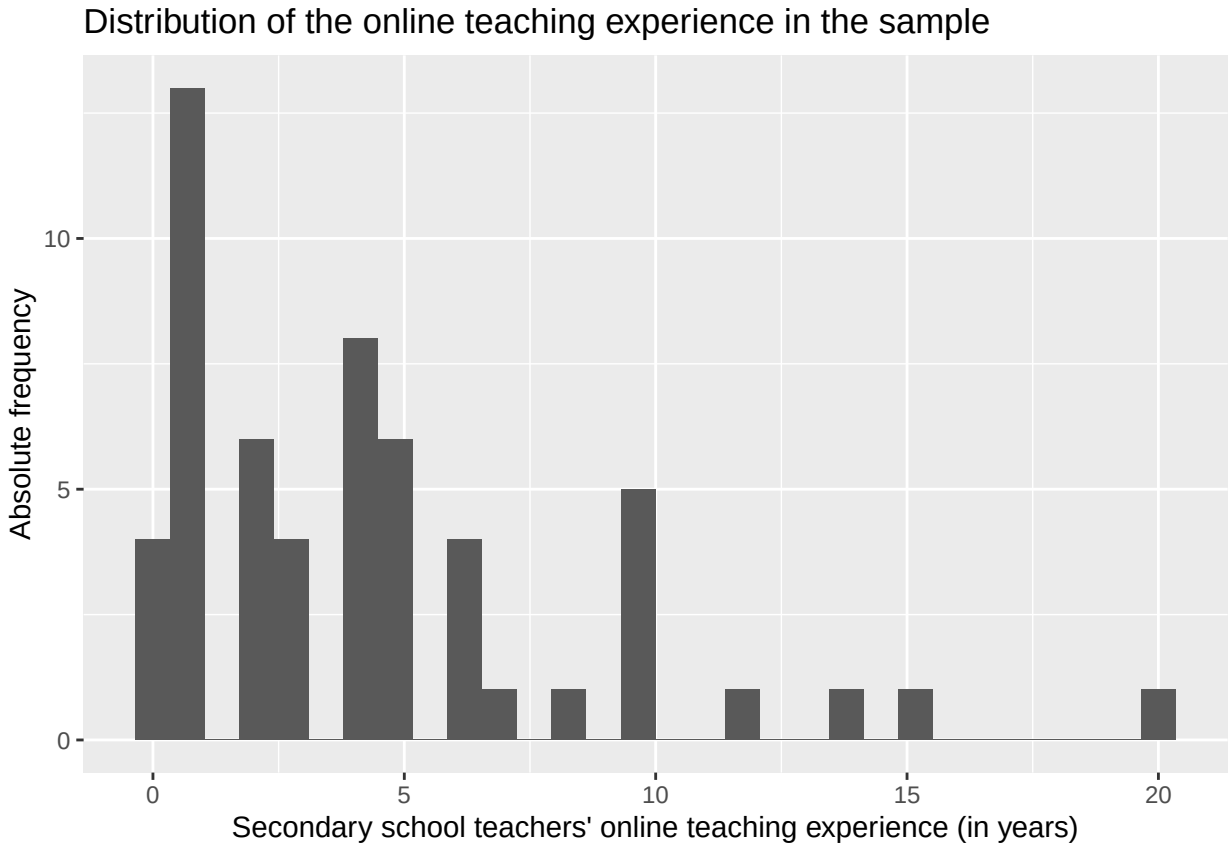
```r
sum(is.na(covid19otlc.tpe$ONTEACHEXP))
```

```
## [1] 166
```

```r
## Exclude due to too many missings

## Histogram
qplot(covid19otlc.tpe$ONTEACHEXP, geom = "histogram",
      main = "Distribution of the online teaching experience in the sample",
      xlab = "Secondary school teachers' online teaching experience (in years)",
      ylab = "Absolute frequency")
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

```
## Warning: Removed 166 rows containing non-finite values (stat_bin).
```




```
############################################################
## Online teaching before COVID-19
table(covid19otlc.tpe$OTLEXP)
```

```
##
##   0   1
## 165  57
```

```
prop.table(table(covid19otlc.tpe$OTLEXP))
```

```
##
##         0         1
## 0.7432432 0.2567568
```

```
############################################################
## Online teaching preparation
summary(covid19otlc.tpe$OTLPREP)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##   0.000   1.000   2.000   4.286   4.000 150.000      12
```

```
table(covid19otlc.tpe$OTLPREP)
```

```
##
##   0   1   2   3   4   5   6   7   8  10  12  14  15  20  21  25  30 150
##  35  31  44  43  14  10   2  11   1   2   1   6   3   1   3   1   1   1
```

```
which(is.na(covid19otlc.tpe$OTLPREP))
```

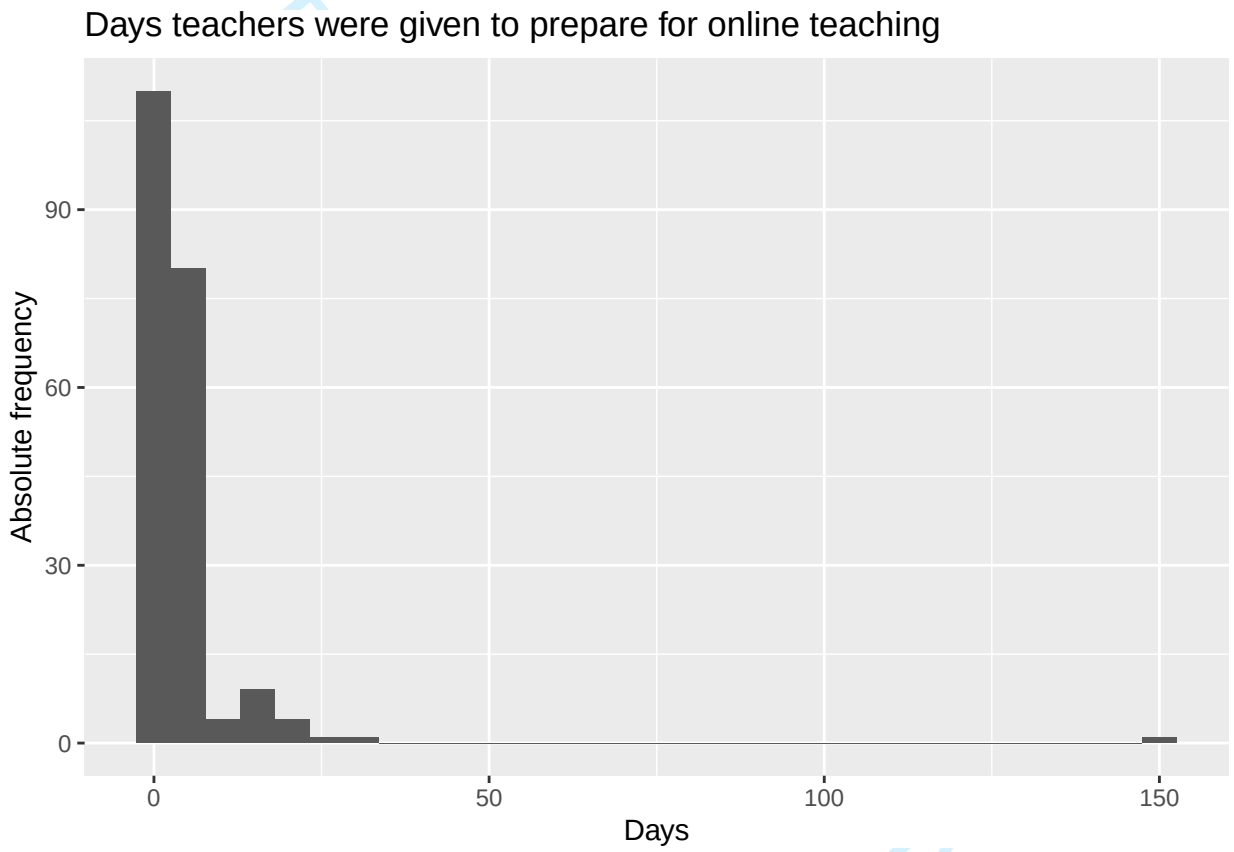
```
##  [1]  47  49  62  67  83  86  95 102 128 163 179 212
```

```r
sum(is.na(covid19otlc.tpe$OTLPREP))
```

```
## [1] 12
```

```r
## Histogram
qplot(covid19otlc.tpe$OTLPREP, geom = "histogram",
      main = "Days teachers were given to prepare for online teaching",
      xlab = "Days",
      ylab = "Absolute frequency")
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## Warning: Removed 12 rows containing non-finite values (stat_bin).
```




```r
############################################################
## Online platform
summary(covid19otlc.tpe$OPLAT)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##   1.000   5.000   5.000   5.564   8.000  10.000     167
```

```r
table(covid19otlc.tpe$OPLAT)
```

```
##
##  1  3  4  5  6  8 10
##  4  7  1 17  9 16  1
```

```r
which(is.na(covid19otlc.tpe$OPLAT))
```

```
##   [1]   1   3   4   5   8  11  12  14  15  17  18  21  22  25  29  31  32  34
```

```
##  [19]  36  37  40  41  43  49  50  51  54  55  56  59  60  61  62  63  64  65
##  [37]  66  67  68  69  70  72  79  80  81  82  83  84  85  86  87  88  89  90
##  [55]  91  92  93  94  95  96  97  98  99 100 101 102 103 104 105 106 107 108
##  [73] 109 110 111 112 113 114 116 117 118 119 120 121 122 123 124 125 126 127
##  [91] 128 131 132 133 134 135 136 137 138 139 140 141 142 144 145 146 148 149
## [109] 150 151 152 153 154 155 157 158 159 160 162 163 164 165 166 167 169 170
## [127] 173 174 175 176 177 178 179 181 182 183 184 185 187 190 191 192 193 194
## [145] 195 196 198 199 200 201 202 203 204 205 206 208 209 211 213 214 215 216
## [163] 217 218 219 220 222
```

```
sum(is.na(covid19otlc.tpe$OPLAT))
```

```
## [1] 167
```

```
## Exclude due to too many missings

############################################################
## Online teaching shift
table(covid19otlc.tpe$OTLSHIFT)
```

```
##
##   0   1   2
##  10  62 150
```

```
prop.table(table(covid19otlc.tpe$OTLSHIFT))
```

```
##
##          0          1          2
## 0.04504505 0.27927928 0.67567568
```

```
############################################################
## Days into online teaching
summary(covid19otlc.tpe$OTLDAYS)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##   0.000   1.000   2.000   1.627   2.000   6.000      10
```

```
table(covid19otlc.tpe$OTLDAYS)
```

```
##
##  0  1  2  3  4  5  6
## 43 50 85 21  7  2  4
```

```
which(is.na(covid19otlc.tpe$OTLDAYS))
```

```
##  [1]  47  49  62  67  86 102 128 163 179 212
```

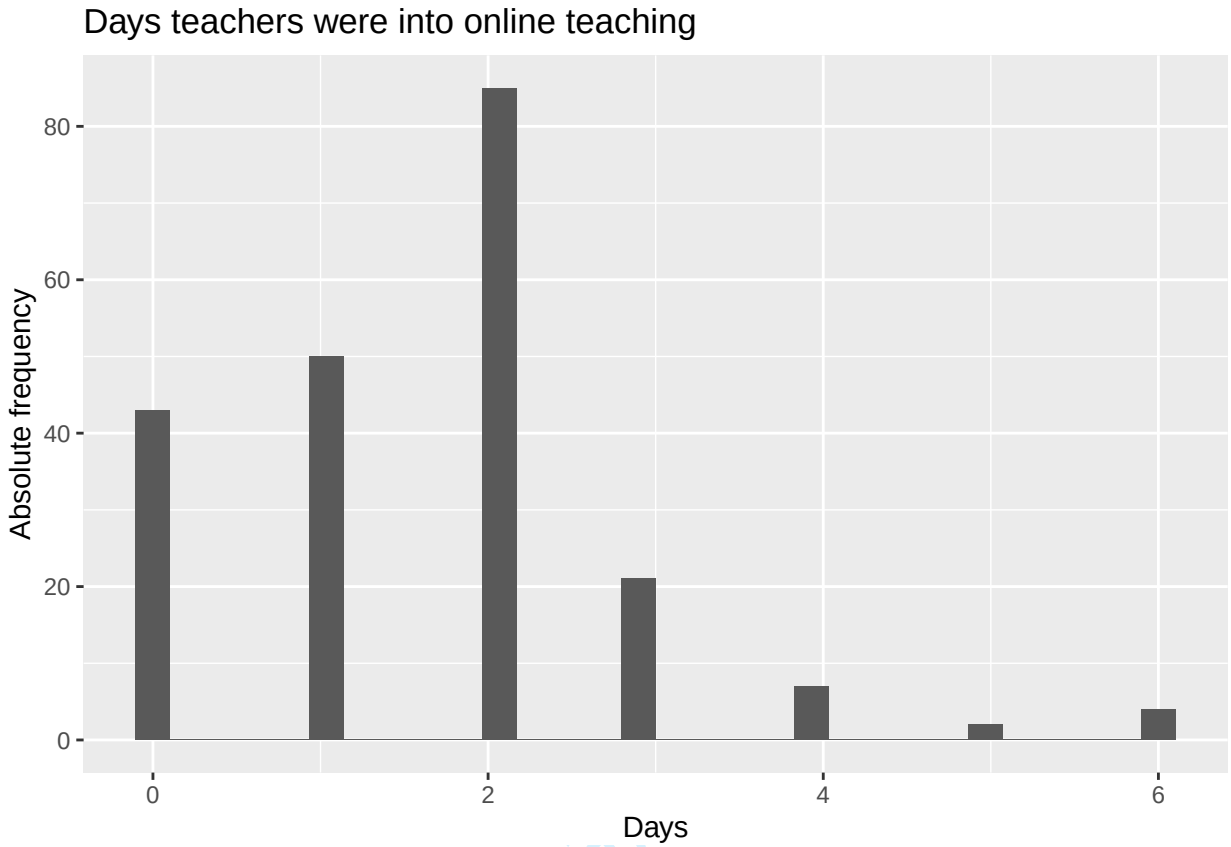
```
sum(is.na(covid19otlc.tpe$OTLDAYS))
```

```
## [1] 10
```

```
## Histogram
qplot(covid19otlc.tpe$OTLDAYS, geom = "histogram",
      main = "Days teachers were into online teaching",
      xlab = "Days",
      ylab = "Absolute frequency")
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

```
## Warning: Removed 10 rows containing non-finite values (stat_bin).
```




```
############################################################
## Institutional decision
table(covid19otlc.tpe$INSTDEC)
```

```
##
##   0   1   2
##  16  52 145
```

```
prop.table(table(covid19otlc.tpe$INSTDEC))
```

```
##
##          0          1          2
## 0.07511737 0.24413146 0.68075117
```

```
############################################################
## Perceived institutional support during COVID-19
# Technical support (PISCO1)
summary(covid19otlc.tpe$PISCO1)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##   0.000   1.000   3.000   2.602   4.000   5.000       1
```

```
table(covid19otlc.tpe$PISCO1)
```

```
##
##  0  1  2  3  4  5
## 32 35 26 51 50 27
```

```
which(is.na(covid19otlc.tpe$PISCO1))
```

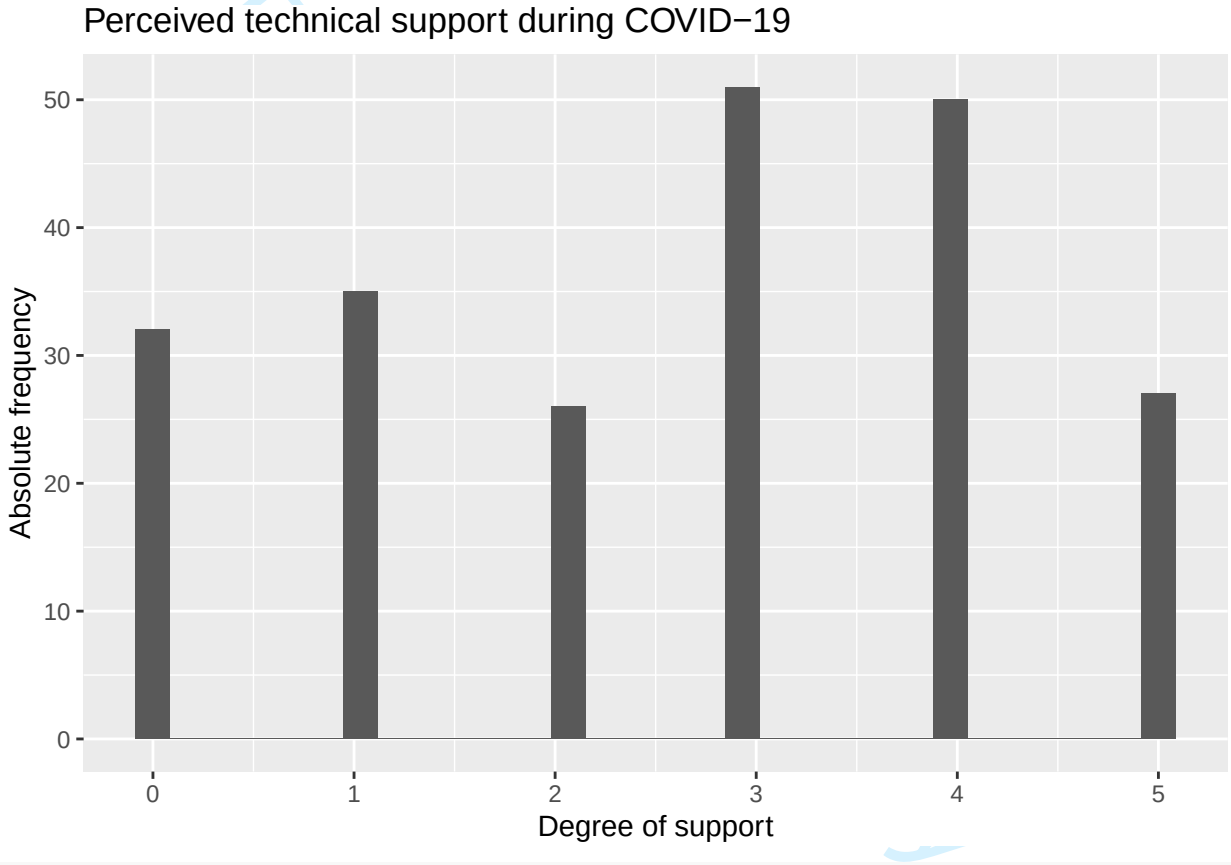
```
## [1] 94
```

```
sum(is.na(covid19otlc.tpe$PISCO1))
```

```
## [1] 1
```

```
## Histogram
qplot(covid19otlc.tpe$PISCO1, geom = "histogram",
      main = "Perceived technical support during COVID-19",
      xlab = "Degree of support",
      ylab = "Absolute frequency")
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## Warning: Removed 1 rows containing non-finite values (stat_bin).
```




```
# Pedagogical support (PISCO2)
summary(covid19otlc.tpe$PISCO2)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##   0.000   1.000   2.000   2.077   3.000   5.000       2
```

```
table(covid19otlc.tpe$PISCO2)
```

```
##
##  0  1  2  3  4  5
## 39 55 39 40 31 16
```

```
which(is.na(covid19otlc.tpe$PISCO2))
```

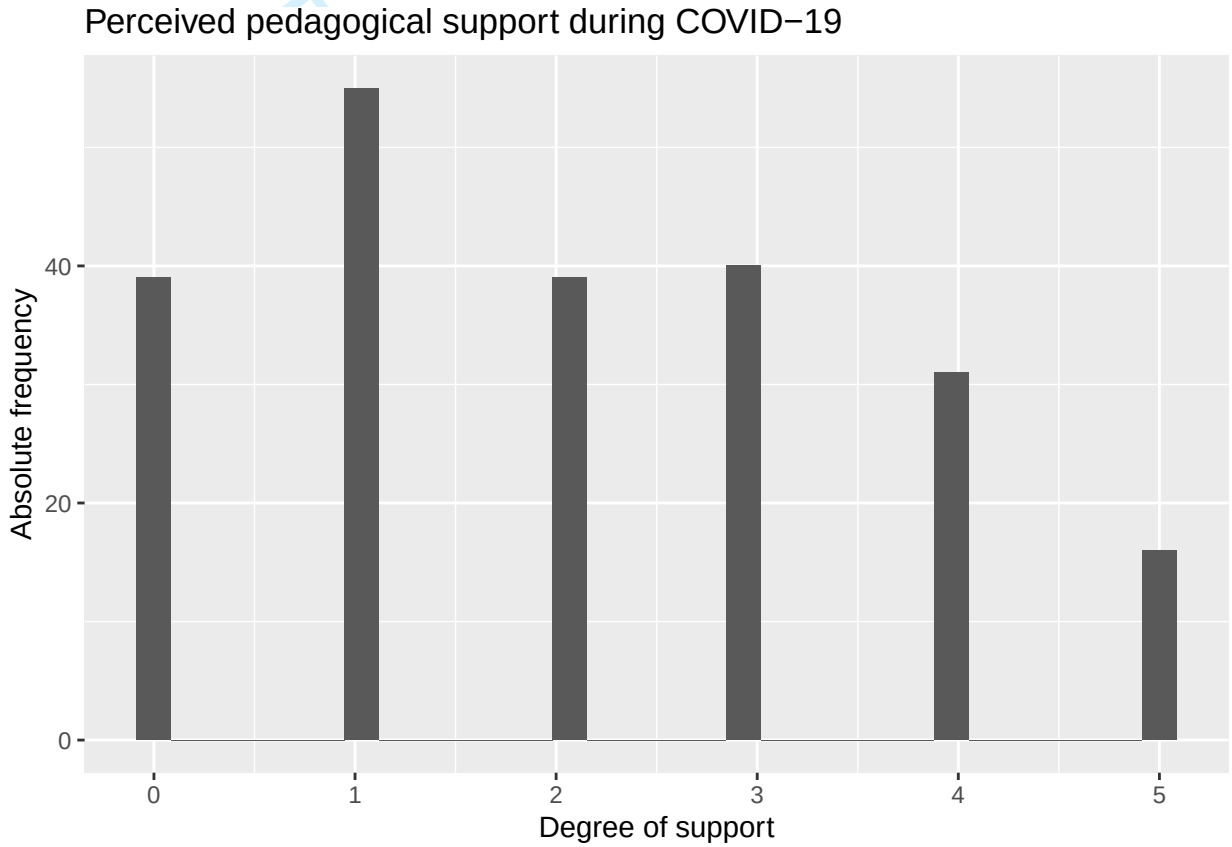
```
## [1] 64 94
```

```r
sum(is.na(covid19otlc.tpe$PISCO2))
```

```
## [1] 2
```

```r
## Histogram
qplot(covid19otlc.tpe$PISCO2, geom = "histogram",
      main = "Perceived pedagogical support during COVID-19",
      xlab = "Degree of support",
      ylab = "Absolute frequency")
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## Warning: Removed 2 rows containing non-finite values (stat_bin).
```




```r
## Correlation
pisco.temp <- data.frame(covid19otlc.tpe$PISCO1, covid19otlc.tpe$PISCO2)
cor(pisco.temp, use = "pairwise.complete.obs")
```

```
##                        covid19otlc.tpe.PISCO1 covid19otlc.tpe.PISCO2
## covid19otlc.tpe.PISCO1              1.0000000              0.6785038
## covid19otlc.tpe.PISCO2              0.6785038              1.0000000
```

```r
############################################################
```

Scales and measurement models

TPACK self-efficacy

```
############################################################
## Select the data
tpack.var <- c("UNPERSID", "TCK1", "TCK2", "TPK1",
               "TPK2", "TPK3", "TPK4", "TPCK1",
               "TPCK2", "TPCK3", "TPCK4")
# Subset the data
tpack <- covid19otlc.tpe[tpack.var]
head(tpack)
```

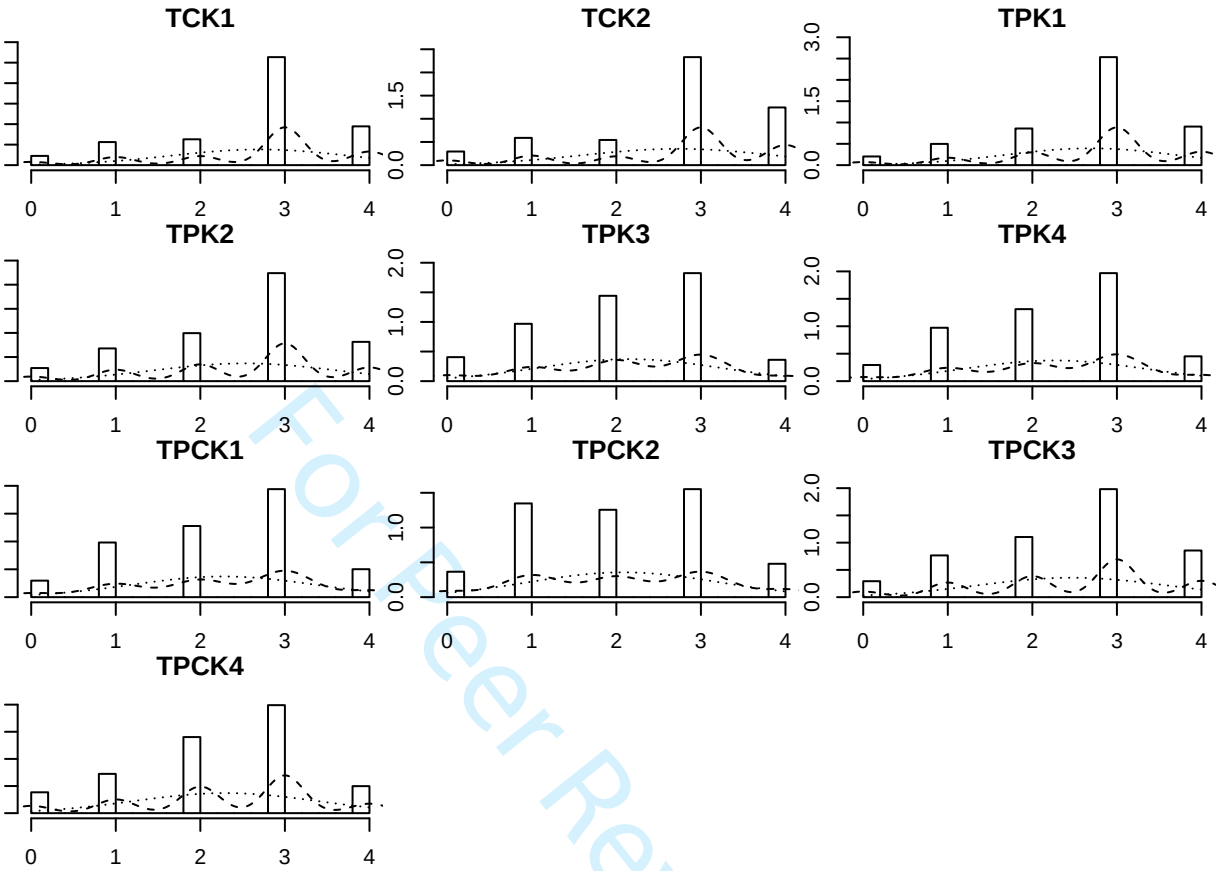
Descriptive scale statistics and correlation matrix

```
##   UNPERSID TCK1 TCK2 TPK1 TPK2 TPK3 TPK4 TPCK1 TPCK2 TPCK3 TPCK4
## 1     4030    2    2    2    2    1    2     2     1     2     1
## 2     4312    4    4    4    4    3    3     3     3     4     2
## 3     4026    3    3    3    3    2    3     3     3     3     2
## 4     4028    0    0    0    0    1    1     0     0     0     1
## 5     4032    3    4    4    3    2    2     2     3     3     3
## 6     4338    1    1    3    1    3    3     2     1     3     0
```

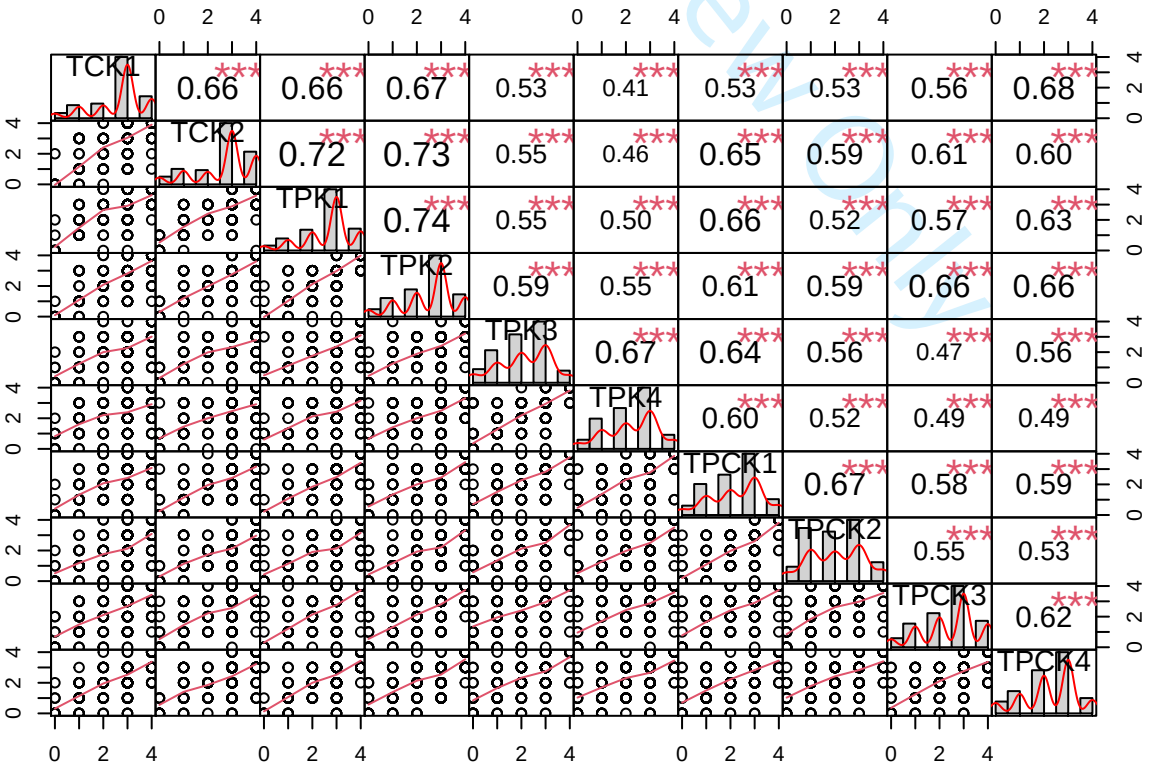
```
############################################################
## Descriptive statistics
describe(tpack[,-1])
```

```
##       vars   n mean   sd median trimmed  mad min max range  skew kurtosis   se
## TCK1     1 222 2.70 1.04      3    2.81 0.00   0   4     4 -0.94     0.31 0.07
## TCK2     2 221 2.73 1.14      3    2.86 1.48   0   4     4 -0.90     0.00 0.08
## TPK1     3 221 2.69 1.01      3    2.79 0.00   0   4     4 -0.87     0.35 0.07
## TPK2     4 221 2.53 1.09      3    2.60 1.48   0   4     4 -0.65    -0.28 0.07
## TPK3     5 222 2.15 1.07      2    2.20 1.48   0   4     4 -0.35    -0.66 0.07
## TPK4     6 221 2.26 1.06      2    2.29 1.48   0   4     4 -0.37    -0.63 0.07
## TPCK1    7 219 2.27 1.07      2    2.29 1.48   0   4     4 -0.36    -0.67 0.07
## TPCK2    8 219 2.09 1.12      2    2.08 1.48   0   4     4 -0.07    -0.93 0.08
## TPCK3    9 222 2.47 1.12      3    2.53 1.48   0   4     4 -0.51    -0.54 0.08
## TPCK4   10 221 2.30 1.08      2    2.34 1.48   0   4     4 -0.50    -0.43 0.07
```

```
## Distributions
multi.hist(tpack[,-1], density = TRUE)
```




```
## Correlation chart
chart.Correlation(tpack[,-1], method = c("pearson"))
```



```
#############################################################
## Correlation matrix
## APA format
apa.cor.table(tpack[,-1], filename="Table_TPACK.doc", table.number=1)
```

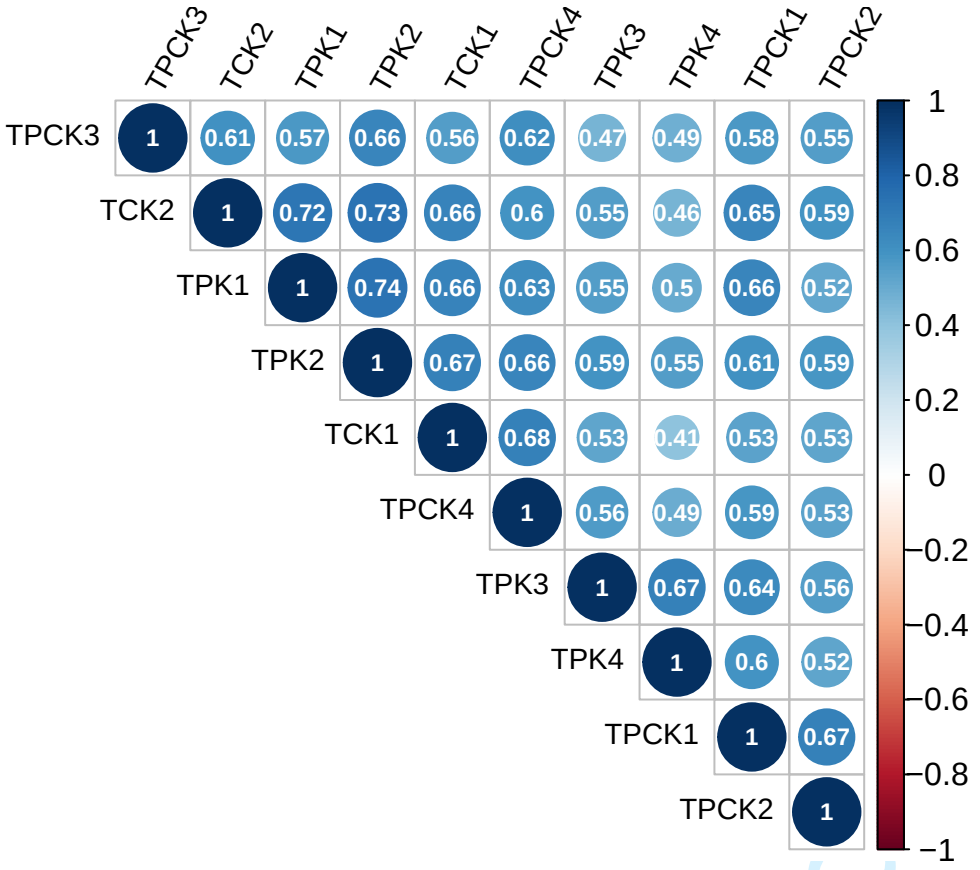
```
##
##
## Table 1
##
## Means, standard deviations, and correlations with confidence intervals
##
##
##   Variable  M    SD   1          2          3          4          5
##   1. TCK1   2.70 1.04
##
##   2. TCK2   2.73 1.14 .66**
##                      [.58, .73]
##
##   3. TPK1   2.69 1.01 .66**      .72**
##                      [.58, .73] [.65, .78]
##
##   4. TPK2   2.53 1.09 .67**      .73**      .74**
##                      [.59, .74] [.67, .79] [.67, .79]
##
##   5. TPK3   2.15 1.07 .53**      .55**      .55**      .59**
##                      [.42, .61] [.45, .64] [.45, .64] [.50, .67]
##
##   6. TPK4   2.26 1.06 .41**      .46**      .50**      .55**      .67**
##                      [.29, .51] [.35, .56] [.39, .59] [.46, .64] [.60, .74]
##
##   7. TPCK1  2.27 1.07 .53**      .65**      .66**      .61**      .64**
##                      [.43, .62] [.57, .72] [.58, .73] [.51, .68] [.55, .71]
##
##   8. TPCK2  2.09 1.12 .53**      .59**      .52**      .59**      .56**
##                      [.43, .62] [.50, .67] [.41, .61] [.50, .67] [.46, .64]
##
##   9. TPCK3  2.47 1.12 .56**      .61**      .57**      .66**      .47**
##                      [.46, .64] [.52, .68] [.48, .66] [.58, .73] [.36, .56]
##
##   10. TPCK4 2.30 1.08 .68**      .60**      .63**      .66**      .56**
##                      [.60, .74] [.50, .68] [.54, .70] [.58, .73] [.46, .65]
##
##   6          7          8          9
##
##
##
##
##
##
##
##
##
##
##
##
```

```
##
##
##
##
##
##
##   .60**
##   [.51, .68]
##
##   .52**      .67**
##   [.42, .61] [.59, .74]
##
##   .49**      .58**      .55**
##   [.38, .58] [.48, .66] [.45, .64]
##
##   .49**      .59**      .53**      .62**
##   [.38, .59] [.50, .67] [.43, .62] [.53, .69]
##
##
## Note. M and SD are used to represent mean and standard deviation, respectively.
## Values in square brackets indicate the 95% confidence interval.
## The confidence interval is a plausible range of population correlations
## that could have caused the sample correlation (Cumming, 2014).
## * indicates p < .05. ** indicates p < .01.
##
```

```
## Extract the Pearson correlation matrix
tpack.cor <- cor(tpack[,-1], method = "pearson",
                 use = "pairwise.complete.obs")
tpack.cor
```

```
##            TCK1      TCK2      TPK1      TPK2      TPK3      TPK4     TPCK1
## TCK1  1.0000000 0.6606659 0.6645667 0.6729717 0.5257304 0.4067114 0.5340474
## TCK2  0.6606659 1.0000000 0.7219284 0.7344307 0.5530358 0.4630667 0.6533737
## TPK1  0.6645667 0.7219284 1.0000000 0.7387180 0.5526445 0.5007214 0.6591281
## TPK2  0.6729717 0.7344307 0.7387180 1.0000000 0.5929535 0.5548643 0.6057073
## TPK3  0.5257304 0.5530358 0.5526445 0.5929535 1.0000000 0.6743857 0.6383886
## TPK4  0.4067114 0.4630667 0.5007214 0.5548643 0.6743857 1.0000000 0.5979701
## TPCK1 0.5340474 0.6533737 0.6591281 0.6057073 0.6383886 0.5979701 1.0000000
## TPCK2 0.5291322 0.5901395 0.5180802 0.5890999 0.5590229 0.5244939 0.6711717
## TPCK3 0.5574571 0.6067277 0.5746924 0.6598349 0.4667902 0.4877856 0.5762563
## TPCK4 0.6758138 0.5962837 0.6272555 0.6594856 0.5612072 0.4920041 0.5899081
##           TPCK2     TPCK3     TPCK4
## TCK1  0.5291322 0.5574571 0.6758138
## TCK2  0.5901395 0.6067277 0.5962837
## TPK1  0.5180802 0.5746924 0.6272555
## TPK2  0.5890999 0.6598349 0.6594856
## TPK3  0.5590229 0.4667902 0.5612072
## TPK4  0.5244939 0.4877856 0.4920041
## TPCK1 0.6711717 0.5762563 0.5899081
## TPCK2 1.0000000 0.5538564 0.5347493
## TPCK3 0.5538564 1.0000000 0.6198639
## TPCK4 0.5347493 0.6198639 1.0000000
```

```
## Correlogram
corrplot(tpack.cor, type = "upper", order = "hclust",
         tl.col = "black", tl.srt = 60,
         addCoef.col = "white",
         number.cex = 0.75,
         cl.cex = 1,
         tl.cex = 0.9)
```




```
## Extract the polychoric correlation matrix
tpack.pcor <- polychoric(tpack[,-1])
```

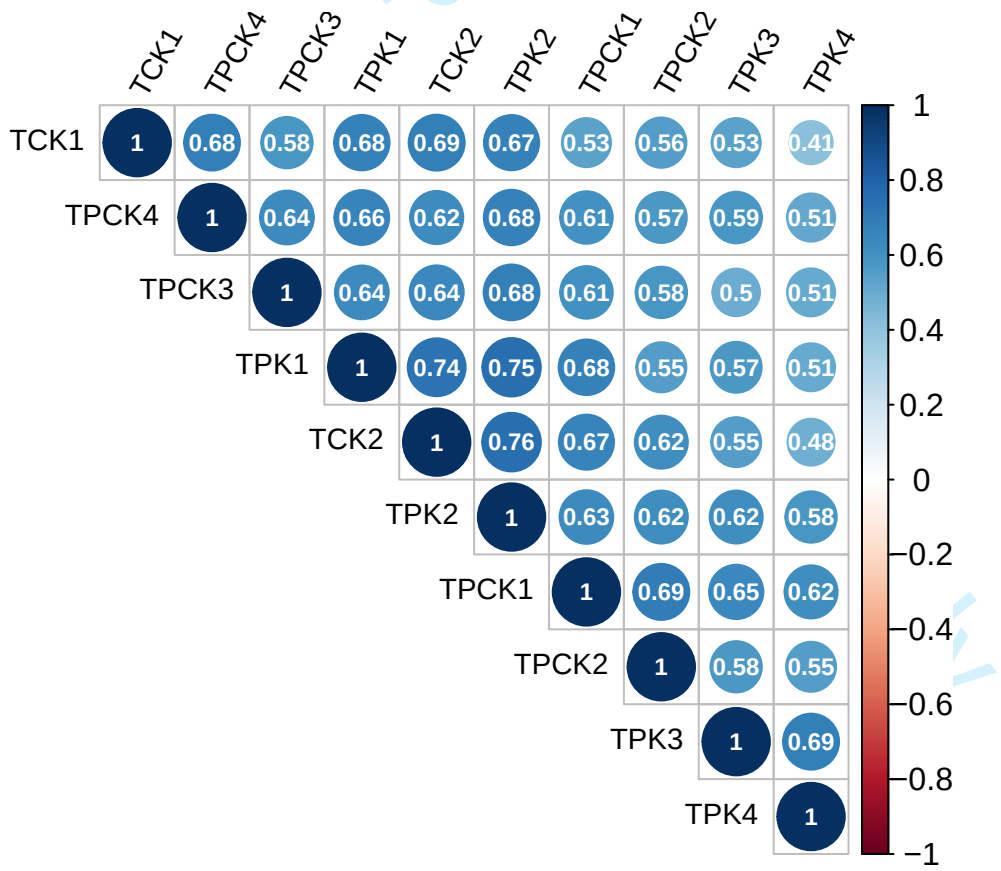
```
## Warning in matpLower(x, nvar, gminx, gmaxx, gminy, gmaxy): 45 cells were
## adjusted for 0 values using the correction for continuity. Examine your data
## carefully.
```

```
tpack.pcor$rho
```

```
##            TCK1      TCK2      TPK1      TPK2      TPK3      TPK4      TPCK1
## TCK1  1.0000000 0.6895030 0.6761606 0.6710236 0.5316646 0.4118257 0.5304530
## TCK2  0.6895030 1.0000000 0.7366626 0.7563828 0.5508784 0.4842826 0.6683122
## TPK1  0.6761606 0.7366626 1.0000000 0.7516079 0.5721284 0.5079311 0.6792814
## TPK2  0.6710236 0.7563828 0.7516079 1.0000000 0.6179921 0.5810783 0.6322127
## TPK3  0.5316646 0.5508784 0.5721284 0.6179921 1.0000000 0.6897338 0.6489077
## TPK4  0.4118257 0.4842826 0.5079311 0.5810783 0.6897338 1.0000000 0.6198556
## TPCK1 0.5304530 0.6683122 0.6792814 0.6322127 0.6489077 0.6198556 1.0000000
## TPCK2 0.5564135 0.6193860 0.5526595 0.6184694 0.5792137 0.5509144 0.6900166
## TPCK3 0.5817922 0.6424128 0.6372721 0.6843066 0.4986829 0.5079580 0.6094933
## TPCK4 0.6847534 0.6228728 0.6616732 0.6776908 0.5854715 0.5115811 0.6064883
```

```
##           TPCK2     TPCK3     TPCK4
## TCK1  0.5564135 0.5817922 0.6847534
## TCK2  0.6193860 0.6424128 0.6228728
## TPK1  0.5526595 0.6372721 0.6616732
## TPK2  0.6184694 0.6843066 0.6776908
## TPK3  0.5792137 0.4986829 0.5854715
## TPK4  0.5509144 0.5079580 0.5115811
## TPCK1 0.6900166 0.6094933 0.6064883
## TPCK2 1.0000000 0.5828841 0.5711546
## TPCK3 0.5828841 1.0000000 0.6377252
## TPCK4 0.5711546 0.6377252 1.0000000
```

```
## Correlogram
corrplot(tpack.pcor$rho, type = "upper", order = "hclust",
         tl.col = "black", tl.srt = 60,
         addCoef.col = "white",
         number.cex = 0.75,
         cl.cex = 1,
         tl.cex = 0.9)
```




```
## Absolute difference between the two matrices
tpack.pcor$rho-tpack.cor
```

```
##              TCK1         TCK2         TPK1         TPK2         TPK3
## TCK1   0.000000000  0.028837064 0.011593955 -0.001948156  0.005934180
## TCK2   0.028837064  0.000000000 0.014734172  0.021952120 -0.002157421
## TPK1   0.011593955  0.014734172 0.000000000  0.012889845  0.019483912
## TPK2  -0.001948156  0.021952120 0.012889845  0.000000000  0.025038574
```

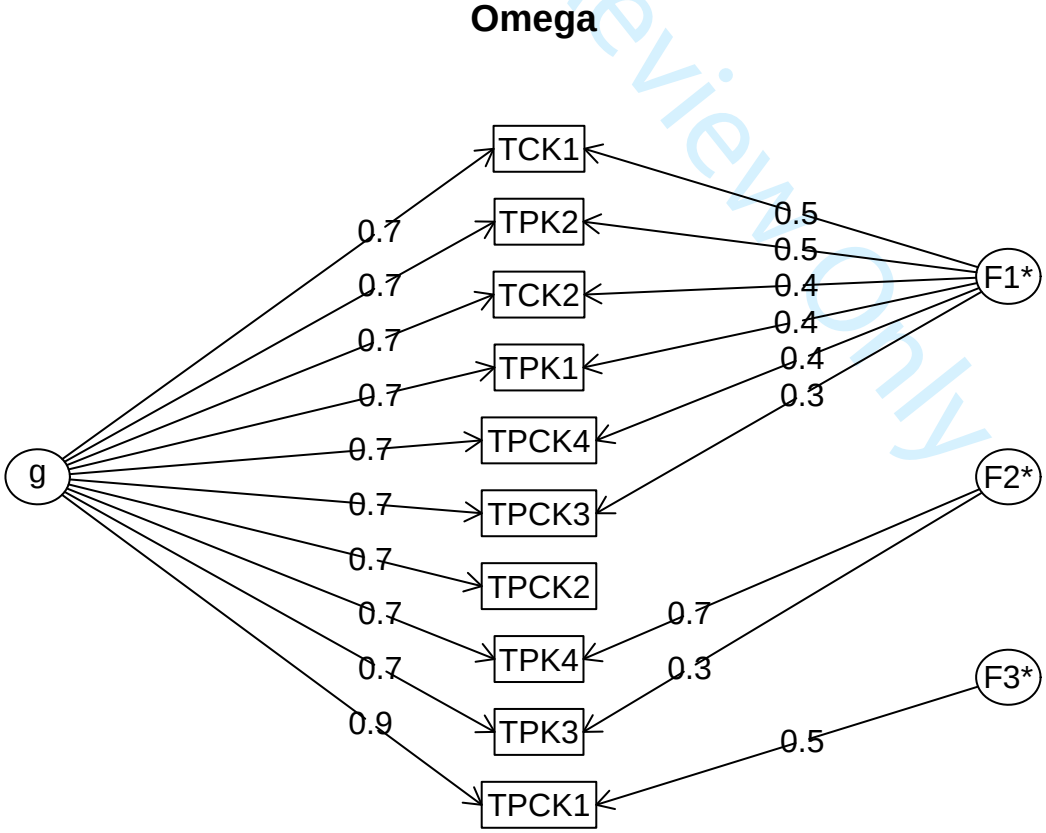
```
## TPK3   0.005934180 -0.002157421 0.019483912  0.025038574  0.000000000
## TPK4   0.005114307  0.021215850 0.007209679  0.026213978  0.015348079
## TPCK1 -0.003594420  0.014938402 0.020153339  0.026505465  0.010519163
## TPCK2  0.027281244  0.029246562 0.034579324  0.029369505  0.020190831
## TPCK3  0.024335044  0.035685157 0.062579677  0.024471728  0.031892714
## TPCK4  0.008939652  0.026589171 0.034417694  0.018205244  0.024264244
##              TPK4       TPCK1      TPCK2      TPCK3       TPCK4
## TCK1  0.005114307 -0.00359442 0.02728124 0.02433504 0.008939652
## TCK2  0.021215850  0.01493840 0.02924656 0.03568516 0.026589171
## TPK1  0.007209679  0.02015334 0.03457932 0.06257968 0.034417694
## TPK2  0.026213978  0.02650546 0.02936951 0.02447173 0.018205244
## TPK3  0.015348079  0.01051916 0.02019083 0.03189271 0.024264244
## TPK4  0.000000000  0.02188543 0.02642047 0.02017238 0.019577007
## TPCK1 0.021885429  0.00000000 0.01884486 0.03323698 0.016580138
## TPCK2 0.026420472  0.01884486 0.00000000 0.02902767 0.036405295
## TPCK3 0.020172377  0.03323698 0.02902767 0.00000000 0.017861271
## TPCK4 0.019577007  0.01658014 0.03640530 0.01786127 0.000000000
```

```
max(tpack.pcor$rho-tpack.cor)
```

```
## [1] 0.06257968
```

```
############################################################
## Reliability coefficients (overall scale)
omega(tpack[,-1])
```

```
## Loading required namespace: GPArotation
```




```
## Omega
```

```
## Call: omegah(m = m, nfactors = nfactors, fm = fm, key = key, flip = flip,
##     digits = digits, title = title, sl = sl, labels = labels,
##     plot = plot, n.obs = n.obs, rotate = rotate, Phi = Phi, option = option,
##     covar = covar)
## Alpha:                 0.93
## G.6:                   0.94
## Omega Hierarchical:    0.79
## Omega H asymptotic:    0.83
## Omega Total            0.95
##
## Schmid Leiman Factor loadings greater than  0.2
##          g   F1*   F2*   F3*   h2   u2   p2
## TCK1  0.65  0.48            0.66 0.34 0.65
## TCK2  0.72  0.41            0.70 0.30 0.75
## TPK1  0.72  0.40            0.68 0.32 0.76
## TPK2  0.74  0.46            0.77 0.23 0.72
## TPK3  0.69        0.30      0.60 0.40 0.80
## TPK4  0.69        0.67      0.92 0.08 0.52
## TPCK1 0.85              0.52 1.00 0.00 0.73
## TPCK2 0.68                   0.54 0.46 0.86
## TPCK3 0.65  0.34             0.54 0.46 0.78
## TPCK4 0.68  0.39             0.62 0.38 0.75
##
## With eigenvalues of:
##    g  F1*  F2*  F3*
## 5.04 1.09 0.56 0.32
##
## general/max  4.63   max/min =   3.38
## mean percent general =  0.73    with sd =  0.09 and cv of  0.13
## Explained Common Variance of the general factor =  0.72
##
## The degrees of freedom are 18  and the fit is  0.18
## The number of observations was  222  with Chi Square =  38.23  with prob <  0.0036
## The root mean square of the residuals is  0.02
## The df corrected root mean square of the residuals is  0.03
## RMSEA index =  0.071  and the 10 % confidence intervals are  0.039 0.103
## BIC =  -59.02
##
## Compare this with the adequacy of just a general factor and no group factors
## The degrees of freedom for just the general factor are 35  and the fit is  1.01
## The number of observations was  222  with Chi Square =  219.24  with prob <  1.5e-28
## The root mean square of the residuals is  0.12
## The df corrected root mean square of the residuals is  0.13
##
## RMSEA index =  0.154  and the 10 % confidence intervals are  0.135 0.174
## BIC =  30.15
##
## Measures of factor score adequacy
##                                                    g  F1*  F2*  F3*
## Correlation of scores with factors             0.92 0.73 0.85 0.77
## Multiple R square of scores with factors       0.84 0.53 0.72 0.60
## Minimum correlation of factor score estimates 0.69 0.06 0.45 0.20
##
##  Total, General and Subset omega for each subset
```

```
##                                                 g  F1*  F2*  F3*
## Omega total for total scores and subscales    0.95 0.92 0.84 1.00
## Omega general for total scores and subscales  0.79 0.71 0.57 0.73
## Omega group for total scores and subscales    0.13 0.21 0.28 0.27
############################################################
```

```
## Model specification
## Three factors
tpack.cfa3 <- '
              # TPACK specific factors
              TCK =~ TCK1 + TCK2
              TPK =~ TPK1 + TPK2 + TPK3 + TPK4
              TPCK =~ TPCK1 + TPCK2 + TPCK3 + TPCK4

              # Residual covariances

'

## Model estimation
tpack.cfa3.fit <- sem(tpack.cfa3, data = tpack[,-1],
                      missing = "FIML",
                      estimator = "MLR",
                      se="robust.mlr")

## Summary
summary(tpack.cfa3.fit,
        rsquare = TRUE,
        fit.measures = TRUE,
        standardized = TRUE)
```

Measurement model

```
## lavaan 0.6-6 ended normally after 47 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         33
##
##   Number of observations                           222
##   Number of missing patterns                         6
##
## Model Test User Model:
##                                                Standard      Robust
##   Test Statistic                                134.349      96.408
##   Degrees of freedom                                 32          32
##   P-value (Chi-square)                            0.000       0.000
##   Scaling correction factor                                   1.394
##         Yuan-Bentler correction (Mplus variant)
##
## Model Test Baseline Model:
##
##   Test statistic                              1554.956    1136.342
##   Degrees of freedom                                 45          45
```

```
##   P-value                                        0.000       0.000
##   Scaling correction factor                                  1.368
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.932       0.941
##   Tucker-Lewis Index (TLI)                       0.905       0.917
##
##   Robust Comparative Fit Index (CFI)                         0.940
##   Robust Tucker-Lewis Index (TLI)                            0.915
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -2588.314   -2588.314
##   Scaling correction factor                                  1.072
##       for the MLR correction
##   Loglikelihood unrestricted model (H1)      -2521.140   -2521.140
##   Scaling correction factor                                  1.230
##       for the MLR correction
##
##   Akaike (AIC)                                5242.628    5242.628
##   Bayesian (BIC)                              5354.916    5354.916
##   Sample-size adjusted Bayesian (BIC)         5250.337    5250.337
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.120       0.095
##   90 Percent confidence interval - lower         0.099       0.077
##   90 Percent confidence interval - upper         0.141       0.114
##   P-value RMSEA <= 0.05                          0.000       0.000
##
##   Robust RMSEA                                               0.112
##   90 Percent confidence interval - lower                     0.087
##   90 Percent confidence interval - upper                     0.139
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.044       0.044
##
## Parameter Estimates:
##
##   Standard errors                             Sandwich
##   Information bread                           Observed
##   Observed information based on                Hessian
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   TCK =~
##     TCK1              1.000                               0.816    0.784
##     TCK2              1.167    0.073   15.901    0.000    0.952    0.841
##   TPK =~
##     TPK1              1.000                               0.853    0.836
##     TPK2              1.113    0.057   19.388    0.000    0.950    0.868
##     TPK3              0.907    0.072   12.600    0.000    0.774    0.722
```

```
##     TPK4              0.826    0.080   10.359    0.000    0.704    0.663
##   TPCK =~
##     TPCK1             1.000                              0.870    0.807
##     TPCK2             0.962    0.054   17.820    0.000    0.837    0.744
##     TPCK3             0.969    0.064   15.229    0.000    0.843    0.754
##     TPCK4             0.975    0.068   14.393    0.000    0.848    0.786
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   TCK ~~
##     TPK               0.682    0.102    6.681    0.000    0.980    0.980
##     TPCK              0.672    0.089    7.548    0.000    0.947    0.947
##   TPK ~~
##     TPCK              0.715    0.091    7.889    0.000    0.964    0.964
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .TCK1              2.703    0.070   38.699    0.000    2.703    2.597
##    .TCK2              2.728    0.076   35.919    0.000    2.728    2.412
##    .TPK1              2.678    0.069   39.019    0.000    2.678    2.626
##    .TPK2              2.518    0.074   34.252    0.000    2.518    2.302
##    .TPK3              2.153    0.072   29.946    0.000    2.153    2.010
##    .TPK4              2.254    0.071   31.543    0.000    2.254    2.121
##    .TPCK1             2.267    0.073   31.219    0.000    2.267    2.102
##    .TPCK2             2.081    0.076   27.485    0.000    2.081    1.850
##    .TPCK3             2.468    0.075   32.910    0.000    2.468    2.209
##    .TPCK4             2.305    0.072   31.796    0.000    2.305    2.135
##     TCK               0.000                              0.000    0.000
##     TPK               0.000                              0.000    0.000
##     TPCK              0.000                              0.000    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .TCK1              0.418    0.056    7.414    0.000    0.418    0.386
##    .TCK2              0.374    0.061    6.177    0.000    0.374    0.292
##    .TPK1              0.312    0.049    6.333    0.000    0.312    0.300
##    .TPK2              0.295    0.048    6.190    0.000    0.295    0.246
##    .TPK3              0.549    0.056    9.735    0.000    0.549    0.479
##    .TPK4              0.634    0.071    8.921    0.000    0.634    0.561
##    .TPCK1             0.407    0.052    7.758    0.000    0.407    0.349
##    .TPCK2             0.566    0.058    9.690    0.000    0.566    0.447
##    .TPCK3             0.538    0.062    8.734    0.000    0.538    0.431
##    .TPCK4             0.446    0.058    7.675    0.000    0.446    0.383
##     TCK               0.665    0.113    5.872    0.000    1.000    1.000
##     TPK               0.727    0.106    6.862    0.000    1.000    1.000
##     TPCK              0.757    0.099    7.623    0.000    1.000    1.000
##
## R-Square:
##                    Estimate
##     TCK1              0.614
##     TCK2              0.708
##     TPK1              0.700
##     TPK2              0.754
##     TPK3              0.521
```

```
##     TPK4              0.439
##     TPCK1             0.651
##     TPCK2             0.553
##     TPCK3             0.569
##     TPCK4             0.617
```

```
## Parameter estimates
parameterEstimates(tpack.cfa3.fit)
```

```
##      lhs op   rhs   est    se      z pvalue ci.lower ci.upper
## 1    TCK =~  TCK1 1.000 0.000     NA     NA    1.000    1.000
## 2    TCK =~  TCK2 1.167 0.073 15.901      0    1.023    1.311
## 3    TPK =~  TPK1 1.000 0.000     NA     NA    1.000    1.000
## 4    TPK =~  TPK2 1.113 0.057 19.388      0    1.001    1.226
## 5    TPK =~  TPK3 0.907 0.072 12.600      0    0.766    1.048
## 6    TPK =~  TPK4 0.826 0.080 10.359      0    0.670    0.982
## 7   TPCK =~ TPCK1 1.000 0.000     NA     NA    1.000    1.000
## 8   TPCK =~ TPCK2 0.962 0.054 17.820      0    0.856    1.067
## 9   TPCK =~ TPCK3 0.969 0.064 15.229      0    0.844    1.094
## 10  TPCK =~ TPCK4 0.975 0.068 14.393      0    0.842    1.107
## 11  TCK1 ~~  TCK1 0.418 0.056  7.414      0    0.307    0.528
## 12  TCK2 ~~  TCK2 0.374 0.061  6.177      0    0.255    0.493
## 13  TPK1 ~~  TPK1 0.312 0.049  6.333      0    0.216    0.409
## 14  TPK2 ~~  TPK2 0.295 0.048  6.190      0    0.201    0.388
## 15  TPK3 ~~  TPK3 0.549 0.056  9.735      0    0.439    0.660
## 16  TPK4 ~~  TPK4 0.634 0.071  8.921      0    0.494    0.773
## 17 TPCK1 ~~ TPCK1 0.407 0.052  7.758      0    0.304    0.509
## 18 TPCK2 ~~ TPCK2 0.566 0.058  9.690      0    0.452    0.681
## 19 TPCK3 ~~ TPCK3 0.538 0.062  8.734      0    0.417    0.659
## 20 TPCK4 ~~ TPCK4 0.446 0.058  7.675      0    0.332    0.560
## 21   TCK ~~   TCK 0.665 0.113  5.872      0    0.443    0.887
## 22   TPK ~~   TPK 0.727 0.106  6.862      0    0.520    0.935
## 23  TPCK ~~  TPCK 0.757 0.099  7.623      0    0.562    0.952
## 24   TCK ~~   TPK 0.682 0.102  6.681      0    0.482    0.882
## 25   TCK ~~  TPCK 0.672 0.089  7.548      0    0.498    0.847
## 26   TPK ~~  TPCK 0.715 0.091  7.889      0    0.537    0.893
## 27  TCK1 ~1       2.703 0.070 38.699      0    2.566    2.840
## 28  TCK2 ~1       2.728 0.076 35.919      0    2.580    2.877
## 29  TPK1 ~1       2.678 0.069 39.019      0    2.543    2.812
## 30  TPK2 ~1       2.518 0.074 34.252      0    2.374    2.662
## 31  TPK3 ~1       2.153 0.072 29.946      0    2.012    2.294
## 32  TPK4 ~1       2.254 0.071 31.543      0    2.114    2.394
## 33 TPCK1 ~1       2.267 0.073 31.219      0    2.125    2.410
## 34 TPCK2 ~1       2.081 0.076 27.485      0    1.933    2.230
## 35 TPCK3 ~1       2.468 0.075 32.910      0    2.321    2.615
## 36 TPCK4 ~1       2.305 0.072 31.796      0    2.163    2.447
## 37   TCK ~1       0.000 0.000     NA     NA    0.000    0.000
## 38   TPK ~1       0.000 0.000     NA     NA    0.000    0.000
## 39  TPCK ~1       0.000 0.000     NA     NA    0.000    0.000
```

```
## Standardized residuals
resid(tpack.cfa3.fit, type="standardized")
```

```
## $type
## [1] "standardized"
##
```

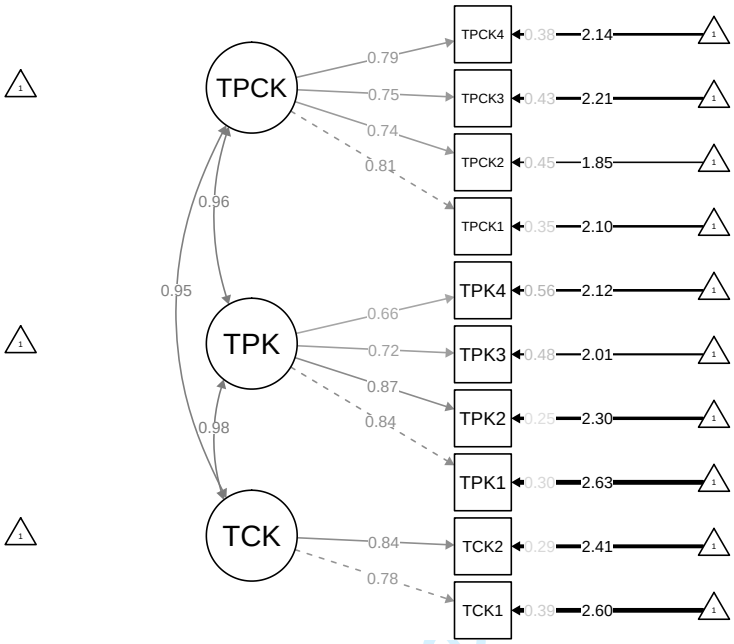
```
## $cov
##       TCK1   TCK2   TPK1   TPK2   TPK3   TPK4   TPCK1  TPCK2  TPCK3  TPCK4
## TCK1   0.000
## TCK2   0.020 -0.006
## TPK1   1.270  1.286  0.049
## TPK2   0.602  1.190  1.142  0.095
## TPK3  -0.976 -1.963 -1.973 -1.335  0.000
## TPK4  -3.660 -3.113 -2.263 -0.745  4.185 -0.032
## TPCK1 -2.415  0.442  0.551 -3.574  2.356  2.226 -0.059
## TPCK2 -0.533  0.043 -2.857 -1.065  1.305  1.344  2.358  0.011
## TPCK3 -0.081  0.112 -0.932  1.348 -1.813  0.350 -0.977  0.053  0.000
## TPCK4  2.959 -1.229  0.087  0.477  0.521 -0.013 -2.036 -1.856  0.900 -0.153
##
## $mean
##   TCK1   TCK2   TPK1   TPK2   TPK3   TPK4  TPCK1  TPCK2  TPCK3  TPCK4
##  0.000 -0.217 -0.967 -1.305  0.000  1.681  0.254  0.302  0.000 -1.907
```

```
## Modification indices
modindices(tpack.cfa3.fit)
```

```
##       lhs op   rhs     mi    epc sepc.lv sepc.all sepc.nox
## 40    TCK =~  TPK1  9.971  3.115   2.540    2.491    2.491
## 41    TCK =~  TPK2  3.903  2.084   1.700    1.554    1.554
## 42    TCK =~  TPK3  5.973 -2.716  -2.215   -2.068   -2.068
## 43    TCK =~  TPK4 21.066 -5.286  -4.311   -4.056   -4.056
## 44    TCK =~ TPCK1  0.560 -0.384  -0.313   -0.291   -0.291
## 45    TCK =~ TPCK2  1.572 -0.659  -0.537   -0.478   -0.478
## 46    TCK =~ TPCK3  0.002 -0.024  -0.019   -0.017   -0.017
## 47    TCK =~ TPCK4  3.993  1.015   0.828    0.767    0.767
## 48    TPK =~  TCK1  0.175 -7.779  -6.635   -6.376   -6.376
## 49    TPK =~  TCK2  0.175  9.064   7.731    6.833    6.833
## 50    TPK =~ TPCK1  0.035 -0.117  -0.100   -0.093   -0.093
## 51    TPK =~ TPCK2  2.708 -1.031  -0.879   -0.782   -0.782
## 52    TPK =~ TPCK3  0.011 -0.064  -0.055   -0.049   -0.049
## 53    TPK =~ TPCK4  3.519  1.148   0.979    0.907    0.907
## 54   TPCK =~  TCK1  0.176  0.235   0.205    0.197    0.197
## 55   TPCK =~  TCK2  0.176 -0.275  -0.239   -0.211   -0.211
## 56   TPCK =~  TPK1  3.088 -0.823  -0.716   -0.702   -0.702
## 57   TPCK =~  TPK2  3.060 -0.879  -0.765   -0.699   -0.699
## 58   TPCK =~  TPK3  3.973  1.045   0.909    0.848    0.848
## 59   TPCK =~  TPK4  7.524  1.487   1.294    1.217    1.217
## 61   TCK1 ~~  TPK1  1.941  0.043   0.043    0.118    0.118
## 62   TCK1 ~~  TPK2  0.563  0.024   0.024    0.067    0.067
## 63   TCK1 ~~  TPK3  0.938 -0.036  -0.036   -0.075   -0.075
## 64   TCK1 ~~  TPK4  8.722 -0.115  -0.115   -0.224   -0.224
## 65   TCK1 ~~ TPCK1  7.103 -0.090  -0.090   -0.219   -0.219
## 66   TCK1 ~~ TPCK2  0.201 -0.017  -0.017   -0.035   -0.035
## 67   TCK1 ~~ TPCK3  0.021 -0.005  -0.005   -0.011   -0.011
## 68   TCK1 ~~ TPCK4 14.776  0.133   0.133    0.309    0.309
## 69   TCK2 ~~  TPK1  4.894  0.069   0.069    0.201    0.201
## 70   TCK2 ~~  TPK2  2.114  0.047   0.047    0.141    0.141
## 71   TCK2 ~~  TPK3  4.071 -0.075  -0.075   -0.165   -0.165
## 72   TCK2 ~~  TPK4  8.010 -0.110  -0.110   -0.226   -0.226
## 73   TCK2 ~~ TPCK1  0.919  0.033   0.033    0.084    0.084
## 74   TCK2 ~~ TPCK2  0.153  0.015   0.015    0.033    0.033
```

```
## 75   TCK2 ~~ TPCK3  0.042  0.008   0.008    0.017    0.017
## 76   TCK2 ~~ TPCK4  3.932 -0.069  -0.069   -0.169   -0.169
## 77   TPK1 ~~  TPK2  2.260  0.048   0.048    0.158    0.158
## 78   TPK1 ~~  TPK3  4.101 -0.067  -0.067   -0.163   -0.163
## 79   TPK1 ~~  TPK4  3.821 -0.068  -0.068   -0.153   -0.153
## 80   TPK1 ~~ TPCK1  1.223  0.033   0.033    0.092    0.092
## 81   TPK1 ~~ TPCK2  8.870 -0.100  -0.100   -0.238   -0.238
## 82   TPK1 ~~ TPCK3  0.955 -0.032  -0.032   -0.078   -0.078
## 83   TPK1 ~~ TPCK4  0.017  0.004   0.004    0.011    0.011
## 84   TPK2 ~~  TPK3  2.065 -0.049  -0.049   -0.123   -0.123
## 85   TPK2 ~~  TPK4  0.461 -0.024  -0.024   -0.056   -0.056
## 86   TPK2 ~~ TPCK1 14.511 -0.115  -0.115   -0.332   -0.332
## 87   TPK2 ~~ TPCK2  0.732 -0.029  -0.029   -0.071   -0.071
## 88   TPK2 ~~ TPCK3  5.140  0.075   0.075    0.189    0.189
## 89   TPK2 ~~ TPCK4  0.313  0.017   0.017    0.048    0.048
## 90   TPK3 ~~  TPK4 38.986  0.269   0.269    0.455    0.455
## 91   TPK3 ~~ TPCK1  9.961  0.116   0.116    0.245    0.245
## 92   TPK3 ~~ TPCK2  2.789  0.070   0.070    0.125    0.125
## 93   TPK3 ~~ TPCK3  5.728 -0.097  -0.097   -0.179   -0.179
## 94   TPK3 ~~ TPCK4  0.044  0.008   0.008    0.016    0.016
## 95   TPK4 ~~ TPCK1  8.325  0.112   0.112    0.221    0.221
## 96   TPK4 ~~ TPCK2  2.556  0.071   0.071    0.118    0.118
## 97   TPK4 ~~ TPCK3  0.007  0.004   0.004    0.006    0.006
## 98   TPK4 ~~ TPCK4  0.284 -0.021  -0.021   -0.040   -0.040
## 99  TPCK1 ~~ TPCK2 12.353  0.142   0.142    0.296    0.296
## 100 TPCK1 ~~ TPCK3  1.438 -0.048  -0.048   -0.102   -0.102
## 101 TPCK1 ~~ TPCK4  3.380 -0.069  -0.069   -0.162   -0.162
## 102 TPCK2 ~~ TPCK3  0.002  0.002   0.002    0.004    0.004
## 103 TPCK2 ~~ TPCK4  2.912 -0.070  -0.070   -0.140   -0.140
## 104 TPCK3 ~~ TPCK4  1.759  0.053   0.053    0.109    0.109
```

```r
# Visualize the path model
semPaths(tpack.cfa3.fit,
         rotation = 2,
         layout = "tree2",
         what = "std",
         posCol = "black",
         edge.width = 0.5,
         style = "Lisrel",
         fade = T,
         edge.label.position = 0.55)
```




```
## Model specification
## One factor
tpack.cfa1 <- '
              # TPACK general factor
              gTPACK =~ TCK1 + TCK2 + TPK1 + TPK2 + TPK3 + TPK4 +
              TPCK1 + TPCK2 + TPCK3 + TPCK4
'

## Model estimation
tpack.cfa1.fit <- sem(tpack.cfa1, data = tpack[,-1],
                      missing = "FIML",
                      estimator = "MLR",
                      se="robust.mlr")

## Summary
summary(tpack.cfa1.fit,
        rsquare = TRUE,
        fit.measures = TRUE,
        standardized = TRUE)
```

```
## lavaan 0.6-6 ended normally after 34 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         30
##
##   Number of observations                           222
##   Number of missing patterns                         6
##
## Model Test User Model:
##                                              Standard      Robust
##   Test Statistic                              141.128      99.374
##   Degrees of freedom                               35          35
##   P-value (Chi-square)                          0.000       0.000
```

```
##   Scaling correction factor                                  1.420
##        Yuan-Bentler correction (Mplus variant)
##
## Model Test Baseline Model:
##
##   Test statistic                              1554.956    1136.342
##   Degrees of freedom                            45          45
##   P-value                                     0.000       0.000
##   Scaling correction factor                               1.368
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                 0.930       0.941
##   Tucker-Lewis Index (TLI)                    0.910       0.924
##
##   Robust Comparative Fit Index (CFI)                      0.939
##   Robust Tucker-Lewis Index (TLI)                         0.921
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -2591.704   -2591.704
##   Scaling correction factor                               1.008
##       for the MLR correction
##   Loglikelihood unrestricted model (H1)      -2521.140   -2521.140
##   Scaling correction factor                               1.230
##       for the MLR correction
##
##   Akaike (AIC)                                5243.408    5243.408
##   Bayesian (BIC)                              5345.488    5345.488
##   Sample-size adjusted Bayesian (BIC)         5250.416    5250.416
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                       0.117       0.091
##   90 Percent confidence interval - lower      0.097       0.074
##   90 Percent confidence interval - upper      0.137       0.109
##   P-value RMSEA <= 0.05                       0.000       0.000
##
##   Robust RMSEA                                            0.108
##   90 Percent confidence interval - lower                  0.084
##   90 Percent confidence interval - upper                  0.134
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                        0.044       0.044
##
## Parameter Estimates:
##
##   Standard errors                            Sandwich
##   Information bread                          Observed
##   Observed information based on               Hessian
##
## Latent Variables:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
```

```
##   gTPACK =~
##     TCK1              1.000                                    0.802    0.771
##     TCK2              1.162    0.072   16.065    0.000    0.932    0.824
##     TPK1              1.054    0.063   16.640    0.000    0.846    0.830
##     TPK2              1.173    0.071   16.574    0.000    0.941    0.860
##     TPK3              0.965    0.083   11.670    0.000    0.774    0.722
##     TPK4              0.880    0.092    9.531    0.000    0.706    0.664
##     TPCK1             1.064    0.087   12.204    0.000    0.853    0.791
##     TPCK2             1.017    0.090   11.317    0.000    0.816    0.725
##     TPCK3             1.032    0.090   11.491    0.000    0.828    0.740
##     TPCK4             1.047    0.073   14.283    0.000    0.840    0.778
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .TCK1              2.703    0.070   38.699    0.000    2.703    2.597
##    .TCK2              2.729    0.076   35.920    0.000    2.729    2.412
##    .TPK1              2.678    0.069   39.016    0.000    2.678    2.626
##    .TPK2              2.518    0.074   34.254    0.000    2.518    2.303
##    .TPK3              2.153    0.072   29.946    0.000    2.153    2.010
##    .TPK4              2.254    0.071   31.539    0.000    2.254    2.120
##    .TPCK1             2.267    0.073   31.225    0.000    2.267    2.102
##    .TPCK2             2.081    0.076   27.480    0.000    2.081    1.849
##    .TPCK3             2.468    0.075   32.910    0.000    2.468    2.209
##    .TPCK4             2.305    0.072   31.794    0.000    2.305    2.136
##     gTPACK            0.000                               0.000    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .TCK1              0.439    0.049    8.893    0.000    0.439    0.406
##    .TCK2              0.411    0.055    7.529    0.000    0.411    0.321
##    .TPK1              0.324    0.051    6.335    0.000    0.324    0.312
##    .TPK2              0.311    0.045    6.858    0.000    0.311    0.260
##    .TPK3              0.549    0.053   10.321    0.000    0.549    0.478
##    .TPK4              0.632    0.068    9.331    0.000    0.632    0.559
##    .TPCK1             0.436    0.052    8.318    0.000    0.436    0.374
##    .TPCK2             0.600    0.057   10.552    0.000    0.600    0.474
##    .TPCK3             0.564    0.062    9.120    0.000    0.564    0.452
##    .TPCK4             0.459    0.057    8.092    0.000    0.459    0.395
##     gTPACK            0.644    0.111    5.808    0.000    1.000    1.000
##
## R-Square:
##                    Estimate
##     TCK1              0.594
##     TCK2              0.679
##     TPK1              0.688
##     TPK2              0.740
##     TPK3              0.522
##     TPK4              0.441
##     TPCK1             0.626
##     TPCK2             0.526
##     TPCK3             0.548
##     TPCK4             0.605
```

```
## Parameter estimates
parameterEstimates(tpack.cfa1.fit)
```

```
##       lhs op    rhs   est    se      z pvalue ci.lower ci.upper
## 1  gTPACK =~   TCK1 1.000 0.000     NA     NA    1.000    1.000
## 2  gTPACK =~   TCK2 1.162 0.072 16.065      0    1.020    1.304
## 3  gTPACK =~   TPK1 1.054 0.063 16.640      0    0.930    1.178
## 4  gTPACK =~   TPK2 1.173 0.071 16.574      0    1.034    1.312
## 5  gTPACK =~   TPK3 0.965 0.083 11.670      0    0.803    1.127
## 6  gTPACK =~   TPK4 0.880 0.092  9.531      0    0.699    1.061
## 7  gTPACK =~  TPCK1 1.064 0.087 12.204      0    0.893    1.235
## 8  gTPACK =~  TPCK2 1.017 0.090 11.317      0    0.841    1.193
## 9  gTPACK =~  TPCK3 1.032 0.090 11.491      0    0.856    1.208
## 10 gTPACK =~  TPCK4 1.047 0.073 14.283      0    0.903    1.190
## 11   TCK1 ~~   TCK1 0.439 0.049  8.893      0    0.342    0.536
## 12   TCK2 ~~   TCK2 0.411 0.055  7.529      0    0.304    0.518
## 13   TPK1 ~~   TPK1 0.324 0.051  6.335      0    0.224    0.424
## 14   TPK2 ~~   TPK2 0.311 0.045  6.858      0    0.222    0.399
## 15   TPK3 ~~   TPK3 0.549 0.053 10.321      0    0.445    0.653
## 16   TPK4 ~~   TPK4 0.632 0.068  9.331      0    0.499    0.764
## 17  TPCK1 ~~  TPCK1 0.436 0.052  8.318      0    0.333    0.538
## 18  TPCK2 ~~  TPCK2 0.600 0.057 10.552      0    0.489    0.712
## 19  TPCK3 ~~  TPCK3 0.564 0.062  9.120      0    0.443    0.685
## 20  TPCK4 ~~  TPCK4 0.459 0.057  8.092      0    0.348    0.571
## 21 gTPACK ~~ gTPACK 0.644 0.111  5.808      0    0.426    0.861
## 22   TCK1 ~1        2.703 0.070 38.699      0    2.566    2.840
## 23   TCK2 ~1        2.729 0.076 35.920      0    2.580    2.878
## 24   TPK1 ~1        2.678 0.069 39.016      0    2.543    2.812
## 25   TPK2 ~1        2.518 0.074 34.254      0    2.374    2.662
## 26   TPK3 ~1        2.153 0.072 29.946      0    2.012    2.294
## 27   TPK4 ~1        2.254 0.071 31.539      0    2.114    2.394
## 28  TPCK1 ~1        2.267 0.073 31.225      0    2.125    2.410
## 29  TPCK2 ~1        2.081 0.076 27.480      0    1.932    2.229
## 30  TPCK3 ~1        2.468 0.075 32.910      0    2.321    2.615
## 31  TPCK4 ~1        2.305 0.072 31.794      0    2.162    2.447
## 32 gTPACK ~1        0.000 0.000     NA     NA    0.000    0.000
```

```
## Standardized residuals
resid(tpack.cfa1.fit, type="standardized")
```

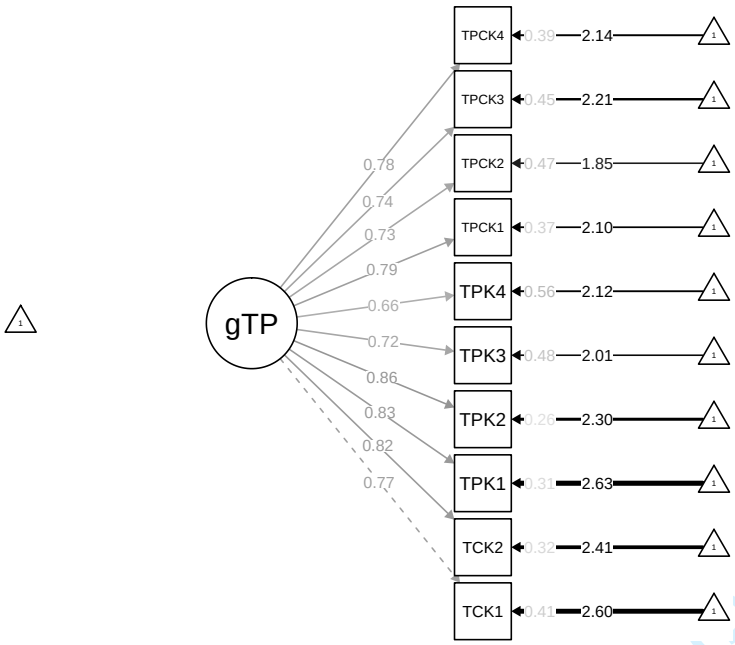
```
## $type
## [1] "standardized"
##
## $cov
##       TCK1   TCK2   TPK1   TPK2   TPK3   TPK4   TPCK1  TPCK2  TPCK3  TPCK4
## TCK1   0.000
## TCK2   0.984 -0.009
## TPK1   1.306  1.325  0.052
## TPK2   0.686  1.359  1.473  0.114
## TPK3  -1.013 -1.897 -1.485 -0.872  0.000
## TPK4  -3.622 -2.971 -1.663 -0.474  4.367 -0.035
## TPCK1 -3.251  0.083  0.332 -4.635  2.051  1.894 -0.060
## TPCK2 -0.842 -0.146 -3.461 -1.272  1.114  1.153  2.854  0.019
## TPCK3 -0.512 -0.232 -1.297  1.197 -2.118  0.083 -0.077  0.697  0.000
## TPCK4  2.411 -2.061 -0.391 -0.087  0.034 -0.459 -0.744 -0.714  1.375 -0.116
```

```
##
## $mean
##   TCK1   TCK2   TPK1   TPK2   TPK3   TPK4  TPCK1  TPCK2  TPCK3  TPCK4
##  0.000 -0.470 -0.878 -1.208  0.000  1.731  0.172  1.081  0.000 -1.184
```

```
## Modification indices
modindices(tpack.cfa1.fit)
```

```
##      lhs op   rhs     mi    epc sepc.lv sepc.all sepc.nox
## 33  TCK1 ~~  TCK2  1.321  0.038   0.038    0.089    0.089
## 34  TCK1 ~~  TPK1  2.542  0.047   0.047    0.125    0.125
## 35  TCK1 ~~  TPK2  0.939  0.029   0.029    0.078    0.078
## 36  TCK1 ~~  TPK3  1.347 -0.042  -0.042   -0.086   -0.086
## 37  TCK1 ~~  TPK4 10.323 -0.124  -0.124   -0.235   -0.235
## 38  TCK1 ~~ TPCK1  8.227 -0.096  -0.096   -0.219   -0.219
## 39  TCK1 ~~ TPCK2  0.669 -0.031  -0.031   -0.061   -0.061
## 40  TCK1 ~~ TPCK3  0.266 -0.019  -0.019   -0.038   -0.038
## 41  TCK1 ~~ TPCK4  9.762  0.106   0.106    0.236    0.236
## 42  TCK2 ~~  TPK1  6.193  0.074   0.074    0.202    0.202
## 43  TCK2 ~~  TPK2  3.078  0.053   0.053    0.148    0.148
## 44  TCK2 ~~  TPK3  3.865 -0.071  -0.071   -0.150   -0.150
## 45  TCK2 ~~  TPK4  8.862 -0.114  -0.114   -0.224   -0.224
## 46  TCK2 ~~ TPCK1  0.040  0.007   0.007    0.016    0.016
## 47  TCK2 ~~ TPCK2  0.017 -0.005  -0.005   -0.010   -0.010
## 48  TCK2 ~~ TPCK3  0.090 -0.011  -0.011   -0.023   -0.023
## 49  TCK2 ~~ TPCK4  4.518 -0.072  -0.072   -0.166   -0.166
## 50  TPK1 ~~  TPK2  3.881  0.053   0.053    0.167    0.167
## 51  TPK1 ~~  TPK3  2.839 -0.054  -0.054   -0.129   -0.129
## 52  TPK1 ~~  TPK4  2.927 -0.058  -0.058   -0.129   -0.129
## 53  TPK1 ~~ TPCK1  0.172  0.012   0.012    0.033    0.033
## 54  TPK1 ~~ TPCK2 10.813 -0.112  -0.112   -0.253   -0.253
## 55  TPK1 ~~ TPCK3  1.977 -0.046  -0.046   -0.108   -0.108
## 56  TPK1 ~~ TPCK4  0.200 -0.014  -0.014   -0.035   -0.035
## 57  TPK2 ~~  TPK3  1.072 -0.034  -0.034   -0.082   -0.082
## 58  TPK2 ~~  TPK4  0.200 -0.015  -0.015   -0.035   -0.035
## 59  TPK2 ~~ TPCK1 15.795 -0.120  -0.120   -0.326   -0.326
## 60  TPK2 ~~ TPCK2  1.855 -0.047  -0.047   -0.108   -0.108
## 61  TPK2 ~~ TPCK3  2.363  0.051   0.051    0.122    0.122
## 62  TPK2 ~~ TPCK4  0.006 -0.002  -0.002   -0.006   -0.006
## 63  TPK3 ~~  TPK4 37.686  0.260   0.260    0.442    0.442
## 64  TPK3 ~~ TPCK1  8.117  0.105   0.105    0.214    0.214
## 65  TPK3 ~~ TPCK2  2.083  0.061   0.061    0.106    0.106
## 66  TPK3 ~~ TPCK3  5.650 -0.097  -0.097   -0.174   -0.174
## 67  TPK3 ~~ TPCK4  0.008  0.003   0.003    0.007    0.007
## 68  TPK4 ~~ TPCK1  7.725  0.108   0.108    0.206    0.206
## 69  TPK4 ~~ TPCK2  2.344  0.068   0.068    0.111    0.111
## 70  TPK4 ~~ TPCK3  0.017  0.006   0.006    0.009    0.009
## 71  TPK4 ~~ TPCK4  0.210 -0.018  -0.018   -0.034   -0.034
## 72 TPCK1 ~~ TPCK2 15.864  0.154   0.154    0.300    0.300
## 73 TPCK1 ~~ TPCK3  0.007 -0.003  -0.003   -0.006   -0.006
## 74 TPCK1 ~~ TPCK4  0.529 -0.025  -0.025   -0.056   -0.056
## 75 TPCK2 ~~ TPCK3  0.759  0.037   0.037    0.064    0.064
## 76 TPCK2 ~~ TPCK4  0.564 -0.030  -0.030   -0.056   -0.056
## 77 TPCK3 ~~ TPCK4  3.254  0.069   0.069    0.135    0.135
```

```r
## Visualize the path model
semPaths(tpack.cfa1.fit,
         rotation = 2,
         layout = "tree2",
         what = "std",
         posCol = "black",
         edge.width = 0.5,
         style = "Lisrel",
         fade = T,
         edge.label.position = 0.55)
```




```r
## Model comparison
anova(tpack.cfa1.fit, tpack.cfa3.fit)
```

```
## Scaled Chi-Squared Difference Test (method = "satorra.bentler.2001")
##
## lavaan NOTE:
##     The "Chisq" column contains standard test statistics, not the
##     robust test that should be reported per model. A robust difference
##     test is a function of two standard (not robust) statistics.
##
##                Df    AIC    BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## tpack.cfa3.fit 32 5242.6 5354.9 134.35
## tpack.cfa1.fit 35 5243.4 5345.5 141.13     3.9781       3     0.2638
```

```r
## Model specification
## Nested-factor model
tpack.nfm <- '
              # TPACK general factor
              gTPACK =~ TCK1 + TCK2 + TPK1 + TPK2 + TPK3 + TPK4 +
              TPCK1 + TPCK2 + TPCK3 + TPCK4

              # TPACK specific factors
              TPK3 ~~  TPK4
```

```
              TPCK1 ~~ TPCK2
              TPK2 ~~ TPCK1
              TCK1 ~~ TPCK1

'

## Model estimation
tpack.nfm.fit <- sem(tpack.nfm, data = tpack[,-1],
                     missing = "FIML",
                     estimator = "MLR",
                     se="robust.mlr")

## Summary
summary(tpack.nfm.fit,
        rsquare = TRUE,
        fit.measures = TRUE,
        standardized = TRUE)
```

```
## lavaan 0.6-6 ended normally after 38 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         34
##
##   Number of observations                           222
##   Number of missing patterns                         6
##
## Model Test User Model:
##                                              Standard      Robust
##   Test Statistic                               61.520      43.763
##   Degrees of freedom                               31          31
##   P-value (Chi-square)                          0.001       0.064
##   Scaling correction factor                                 1.406
##         Yuan-Bentler correction (Mplus variant)
##
## Model Test Baseline Model:
##
##   Test statistic                             1554.956    1136.342
##   Degrees of freedom                               45          45
##   P-value                                       0.000       0.000
##   Scaling correction factor                                 1.368
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                   0.980       0.988
##   Tucker-Lewis Index (TLI)                      0.971       0.983
##
##   Robust Comparative Fit Index (CFI)                        0.988
##   Robust Tucker-Lewis Index (TLI)                           0.983
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -2551.900   -2551.900
##   Scaling correction factor                                 1.070
```

```
##       for the MLR correction
##   Loglikelihood unrestricted model (H1)      -2521.140   -2521.140
##   Scaling correction factor                                  1.230
##       for the MLR correction
##
##   Akaike (AIC)                                5171.800    5171.800
##   Bayesian (BIC)                              5287.491    5287.491
##   Sample-size adjusted Bayesian (BIC)         5179.742    5179.742
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.067       0.043
##   90 Percent confidence interval - lower         0.042       0.011
##   90 Percent confidence interval - upper         0.091       0.066
##   P-value RMSEA <= 0.05                          0.125       0.660
##
##   Robust RMSEA                                               0.051
##   90 Percent confidence interval - lower                        NA
##   90 Percent confidence interval - upper                     0.084
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.031       0.031
##
## Parameter Estimates:
##
##   Standard errors                             Sandwich
##   Information bread                           Observed
##   Observed information based on                Hessian
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   gTPACK =~
##     TCK1              1.000                               0.820    0.788
##     TCK2              1.137    0.070   16.158    0.000    0.932    0.824
##     TPK1              1.038    0.063   16.607    0.000    0.852    0.835
##     TPK2              1.173    0.071   16.497    0.000    0.962    0.880
##     TPK3              0.919    0.076   12.020    0.000    0.754    0.703
##     TPK4              0.829    0.085    9.785    0.000    0.680    0.640
##     TPCK1             1.067    0.085   12.587    0.000    0.875    0.813
##     TPCK2             0.961    0.085   11.356    0.000    0.788    0.700
##     TPCK3             1.000    0.085   11.800    0.000    0.820    0.734
##     TPCK4             1.016    0.070   14.434    0.000    0.833    0.772
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .TPK3 ~~
##    .TPK4             0.260    0.053    4.916    0.000    0.260    0.418
##  .TPCK1 ~~
##    .TPCK2            0.114    0.048    2.369    0.018    0.114    0.226
##  .TPK2 ~~
##    .TPCK1           -0.121    0.034   -3.497    0.000   -0.121   -0.370
##  .TCK1 ~~
##    .TPCK1           -0.112    0.033   -3.432    0.001   -0.112   -0.279
```

```
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .TCK1              2.703    0.070   38.699    0.000    2.703    2.597
##    .TCK2              2.728    0.076   35.911    0.000    2.728    2.411
##    .TPK1              2.678    0.069   39.008    0.000    2.678    2.626
##    .TPK2              2.518    0.074   34.235    0.000    2.518    2.301
##    .TPK3              2.153    0.072   29.946    0.000    2.153    2.010
##    .TPK4              2.254    0.071   31.536    0.000    2.254    2.121
##    .TPCK1             2.267    0.073   31.259    0.000    2.267    2.106
##    .TPCK2             2.081    0.076   27.492    0.000    2.081    1.849
##    .TPCK3             2.468    0.075   32.910    0.000    2.468    2.209
##    .TPCK4             2.304    0.072   31.804    0.000    2.304    2.136
##     gTPACK            0.000                               0.000    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .TCK1              0.410    0.049    8.380    0.000    0.410    0.379
##    .TCK2              0.411    0.054    7.584    0.000    0.411    0.321
##    .TPK1              0.315    0.050    6.353    0.000    0.315    0.303
##    .TPK2              0.271    0.040    6.718    0.000    0.271    0.226
##    .TPK3              0.580    0.054   10.678    0.000    0.580    0.505
##    .TPK4              0.667    0.068    9.879    0.000    0.667    0.590
##    .TPCK1             0.393    0.050    7.815    0.000    0.393    0.339
##    .TPCK2             0.646    0.061   10.588    0.000    0.646    0.510
##    .TPCK3             0.576    0.062    9.302    0.000    0.576    0.461
##    .TPCK4             0.469    0.056    8.354    0.000    0.469    0.403
##     gTPACK            0.673    0.112    6.018    0.000    1.000    1.000
##
## R-Square:
##                    Estimate
##     TCK1              0.621
##     TCK2              0.679
##     TPK1              0.697
##     TPK2              0.774
##     TPK3              0.495
##     TPK4              0.410
##     TPCK1             0.661
##     TPCK2             0.490
##     TPCK3             0.539
##     TPCK4             0.597
```

```
## Parameter estimates
parameterEstimates(tpack.nfm.fit)
```

```
##       lhs op    rhs    est    se      z pvalue ci.lower ci.upper
## 1  gTPACK =~   TCK1  1.000 0.000     NA     NA    1.000    1.000
## 2  gTPACK =~   TCK2  1.137 0.070 16.158  0.000    0.999    1.274
## 3  gTPACK =~   TPK1  1.038 0.063 16.607  0.000    0.916    1.161
## 4  gTPACK =~   TPK2  1.173 0.071 16.497  0.000    1.034    1.313
## 5  gTPACK =~   TPK3  0.919 0.076 12.020  0.000    0.769    1.069
## 6  gTPACK =~   TPK4  0.829 0.085  9.785  0.000    0.663    0.995
## 7  gTPACK =~ TPCK1  1.067 0.085 12.587  0.000    0.901    1.233
## 8  gTPACK =~ TPCK2  0.961 0.085 11.356  0.000    0.795    1.126
## 9  gTPACK =~ TPCK3  1.000 0.085 11.800  0.000    0.834    1.166
```

```
## 10 gTPACK =~  TPCK4  1.016 0.070 14.434  0.000    0.878    1.154
## 11   TPK3 ~~   TPK4  0.260 0.053  4.916  0.000    0.156    0.364
## 12  TPCK1 ~~  TPCK2  0.114 0.048  2.369  0.018    0.020    0.208
## 13   TPK2 ~~  TPCK1 -0.121 0.034 -3.497  0.000   -0.188   -0.053
## 14   TCK1 ~~  TPCK1 -0.112 0.033 -3.432  0.001   -0.176   -0.048
## 15   TCK1 ~~   TCK1  0.410 0.049  8.380  0.000    0.314    0.506
## 16   TCK2 ~~   TCK2  0.411 0.054  7.584  0.000    0.305    0.517
## 17   TPK1 ~~   TPK1  0.315 0.050  6.353  0.000    0.218    0.412
## 18   TPK2 ~~   TPK2  0.271 0.040  6.718  0.000    0.192    0.350
## 19   TPK3 ~~   TPK3  0.580 0.054 10.678  0.000    0.473    0.686
## 20   TPK4 ~~   TPK4  0.667 0.068  9.879  0.000    0.535    0.800
## 21  TPCK1 ~~  TPCK1  0.393 0.050  7.815  0.000    0.294    0.491
## 22  TPCK2 ~~  TPCK2  0.646 0.061 10.588  0.000    0.526    0.765
## 23  TPCK3 ~~  TPCK3  0.576 0.062  9.302  0.000    0.455    0.698
## 24  TPCK4 ~~  TPCK4  0.469 0.056  8.354  0.000    0.359    0.579
## 25 gTPACK ~~ gTPACK  0.673 0.112  6.018  0.000    0.454    0.892
## 26   TCK1 ~1         2.703 0.070 38.699  0.000    2.566    2.840
## 27   TCK2 ~1         2.728 0.076 35.911  0.000    2.579    2.877
## 28   TPK1 ~1         2.678 0.069 39.008  0.000    2.543    2.812
## 29   TPK2 ~1         2.518 0.074 34.235  0.000    2.374    2.662
## 30   TPK3 ~1         2.153 0.072 29.946  0.000    2.012    2.294
## 31   TPK4 ~1         2.254 0.071 31.536  0.000    2.114    2.394
## 32  TPCK1 ~1         2.267 0.073 31.259  0.000    2.125    2.409
## 33  TPCK2 ~1         2.081 0.076 27.492  0.000    1.933    2.230
## 34  TPCK3 ~1         2.468 0.075 32.910  0.000    2.321    2.615
## 35  TPCK4 ~1         2.304 0.072 31.804  0.000    2.162    2.446
## 36 gTPACK ~1         0.000 0.000     NA     NA    0.000    0.000
```

```
## Standardized residuals
resid(tpack.nfm.fit, type="standardized")
```

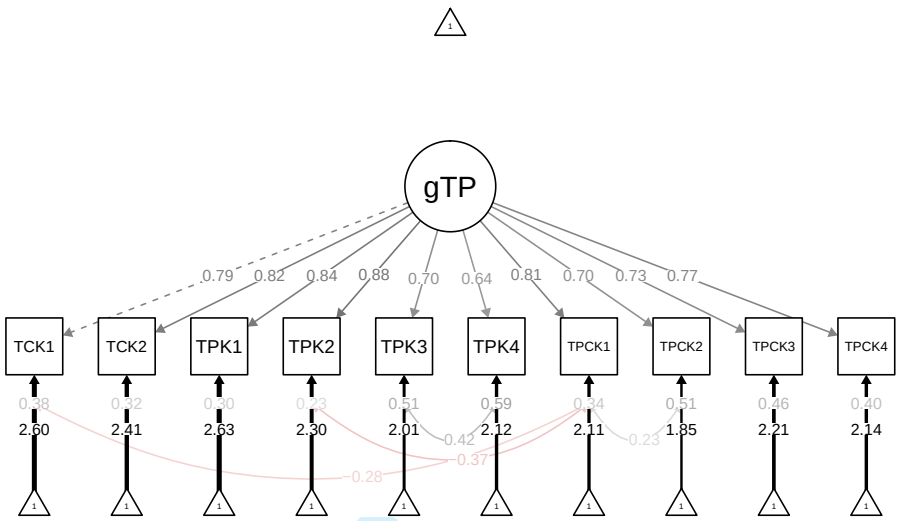
```
## $type
## [1] "standardized"
##
## $cov
##       TCK1   TCK2   TPK1   TPK2   TPK3   TPK4   TPCK1  TPCK2  TPCK3  TPCK4
## TCK1   0.000
## TCK2   0.440 -0.006
## TPK1   0.639  1.211  0.032
## TPK2  -0.637  0.658  0.504  0.023
## TPK3  -0.870 -1.097 -0.910 -0.720  0.000
## TPK4  -2.969 -1.927 -0.924 -0.089 -0.044 -0.052
## TPCK1  0.206 -0.644 -0.700  0.047  2.127  2.167  0.170
## TPCK2 -0.574  0.581 -2.354 -0.987  1.673  1.733  1.025  0.004
## TPCK3 -0.833 -0.018 -1.198  0.978 -1.354  0.636 -0.388  1.288  0.000
## TPCK4  2.329 -1.864 -0.390 -0.680  0.571  0.204 -1.184  0.108  1.602 -0.073
##
## $mean
##   TCK1   TCK2   TPK1   TPK2   TPK3   TPK4  TPCK1  TPCK2  TPCK3  TPCK4
##  0.000 -0.079 -0.492 -0.168  0.000  1.922  1.101  0.227  0.000 -0.747
```

```
## Modification indices
modindices(tpack.nfm.fit)
```

```
##      lhs op   rhs    mi    epc sepc.lv sepc.all sepc.nox
## 37  TCK1 ~~  TCK2 0.094  0.010   0.010    0.025    0.025
```

```
## 38  TCK1 ~~  TPK1 0.710  0.025   0.025    0.069    0.069
## 39  TCK1 ~~  TPK2 0.656 -0.024  -0.024   -0.071   -0.071
## 40  TCK1 ~~  TPK3 0.377  0.020   0.020    0.041    0.041
## 41  TCK1 ~~  TPK4 5.706 -0.082  -0.082   -0.157   -0.157
## 42  TCK1 ~~ TPCK2 0.330 -0.022  -0.022   -0.043   -0.043
## 43  TCK1 ~~ TPCK3 1.299 -0.042  -0.042   -0.087   -0.087
## 44  TCK1 ~~ TPCK4 6.693  0.088   0.088    0.201    0.201
## 45  TCK2 ~~  TPK1 4.881  0.063   0.063    0.176    0.176
## 46  TCK2 ~~  TPK2 0.390  0.019   0.019    0.057    0.057
## 47  TCK2 ~~  TPK3 0.179 -0.014  -0.014   -0.028   -0.028
## 48  TCK2 ~~  TPK4 2.870 -0.058  -0.058   -0.111   -0.111
## 49  TCK2 ~~ TPCK1 0.632 -0.028  -0.028   -0.069   -0.069
## 50  TCK2 ~~ TPCK2 0.648  0.030   0.030    0.058    0.058
## 51  TCK2 ~~ TPCK3 0.001 -0.001  -0.001   -0.002   -0.002
## 52  TCK2 ~~ TPCK4 3.371 -0.061  -0.061   -0.140   -0.140
## 53  TPK1 ~~  TPK2 0.777  0.024   0.024    0.082    0.082
## 54  TPK1 ~~  TPK3 0.558 -0.021  -0.021   -0.050   -0.050
## 55  TPK1 ~~  TPK4 0.347 -0.018  -0.018   -0.039   -0.039
## 56  TPK1 ~~ TPCK1 0.118  0.011   0.011    0.030    0.030
## 57  TPK1 ~~ TPCK2 5.744 -0.079  -0.079   -0.175   -0.175
## 58  TPK1 ~~ TPCK3 1.728 -0.042  -0.042   -0.099   -0.099
## 59  TPK1 ~~ TPCK4 0.179 -0.012  -0.012   -0.033   -0.033
## 60  TPK2 ~~  TPK3 0.160 -0.012  -0.012   -0.029   -0.029
## 61  TPK2 ~~  TPK4 0.822  0.028   0.028    0.065    0.065
## 62  TPK2 ~~ TPCK2 1.011 -0.035  -0.035   -0.084   -0.084
## 63  TPK2 ~~ TPCK3 0.697  0.028   0.028    0.071    0.071
## 64  TPK2 ~~ TPCK4 1.365 -0.036  -0.036   -0.102   -0.102
## 65  TPK3 ~~ TPCK1 2.310  0.049   0.049    0.102    0.102
## 66  TPK3 ~~ TPCK2 1.055  0.038   0.038    0.062    0.062
## 67  TPK3 ~~ TPCK3 4.524 -0.079  -0.079   -0.136   -0.136
## 68  TPK3 ~~ TPCK4 0.440  0.022   0.022    0.043    0.043
## 69  TPK4 ~~ TPCK1 1.770  0.045   0.045    0.087    0.087
## 70  TPK4 ~~ TPCK2 1.393  0.047   0.047    0.071    0.071
## 71  TPK4 ~~ TPCK3 2.540  0.063   0.063    0.101    0.101
## 72  TPK4 ~~ TPCK4 0.000  0.000   0.000   -0.001   -0.001
## 73 TPCK1 ~~ TPCK3 1.138 -0.040  -0.040   -0.084   -0.084
## 74 TPCK1 ~~ TPCK4 1.292 -0.040  -0.040   -0.092   -0.092
## 75 TPCK2 ~~ TPCK3 2.969  0.072   0.072    0.119    0.119
## 76 TPCK2 ~~ TPCK4 0.107  0.013   0.013    0.023    0.023
## 77 TPCK3 ~~ TPCK4 4.260  0.078   0.078    0.151    0.151
```

```r
# Visualize the path model
semPaths(tpack.nfm.fit,
         rotation = 1,
         layout = "tree2",
         what = "std",
         posCol = "black",
         edge.width = 0.5,
         style = "Lisrel",
         fade = T,
         edge.label.position = 0.55)
```




```
## Model comparison
anova(tpack.cfa1.fit, tpack.nfm.fit)
```

```
## Scaled Chi-Squared Difference Test (method = "satorra.bentler.2001")
##
## lavaan NOTE:
##     The "Chisq" column contains standard test statistics, not the
##     robust test that should be reported per model. A robust difference
##     test is a function of two standard (not robust) statistics.
##
##                Df    AIC    BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## tpack.nfm.fit  31 5171.8 5287.5  61.52
## tpack.cfa1.fit 35 5243.4 5345.5 141.13     51.965       4  1.403e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Model specification
tpack.cfa1m <- '
              # TPACK general factor
              gTPACK =~ TCK1 + TCK2 + TPK1 + TPK2 + TPK3 + TPK4 +
              TPCK1 + TPCK2 + TPCK3 + TPCK4

              # residual covariance
              TPK3 ~~ TPK4
'


## Model estimation with categorical data treatment
tpack.cfa1.fitc <- sem(tpack.cfa1m, data = tpack[,-1],
                       ordered = c("TCK1", "TCK2", "TPK1",
                                   "TPK2", "TPK3", "TPK4", "TPCK1",
                                   "TPCK2", "TPCK3", "TPCK4"),
                       estimator = "WLSMV")

## Summary
summary(tpack.cfa1.fitc,
        rsquare = TRUE,
        fit.measures = TRUE,
```

```
        standardized = TRUE)
```

```
## lavaan 0.6-6 ended normally after 29 iterations
##
##   Estimator                                         DWLS
##   Optimization method                              NLMINB
##   Number of free parameters                            51
##
##                                                     Used       Total
##   Number of observations                             215         222
##
## Model Test User Model:
##                                                  Standard      Robust
##   Test Statistic                                   46.487      96.916
##   Degrees of freedom                                   34          34
##   P-value (Chi-square)                              0.075       0.000
##   Scaling correction factor                                     0.517
##   Shift parameter                                               6.926
##        simple second-order correction
##
## Model Test Baseline Model:
##
##   Test statistic                                13590.290    4771.316
##   Degrees of freedom                                   45          45
##   P-value                                           0.000       0.000
##   Scaling correction factor                                     2.866
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                       0.999       0.987
##   Tucker-Lewis Index (TLI)                          0.999       0.982
##
##   Robust Comparative Fit Index (CFI)                               NA
##   Robust Tucker-Lewis Index (TLI)                                  NA
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                             0.041       0.093
##   90 Percent confidence interval - lower            0.000       0.072
##   90 Percent confidence interval - upper            0.069       0.115
##   P-value RMSEA <= 0.05                             0.665       0.001
##
##   Robust RMSEA                                                     NA
##   90 Percent confidence interval - lower                           NA
##   90 Percent confidence interval - upper                           NA
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                              0.039       0.039
##
## Parameter Estimates:
##
##   Standard errors                             Robust.sem
##   Information                                   Expected
```

```
##   Information saturated (h1) model        Unstructured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   gTPACK =~
##     TCK1              1.000                               0.818    0.818
##     TCK2              1.055    0.035   30.536    0.000    0.863    0.863
##     TPK1              1.078    0.040   26.689    0.000    0.882    0.882
##     TPK2              1.107    0.038   29.259    0.000    0.906    0.906
##     TPK3              0.905    0.039   23.060    0.000    0.741    0.741
##     TPK4              0.841    0.046   18.178    0.000    0.688    0.688
##     TPCK1             1.041    0.040   25.948    0.000    0.852    0.852
##     TPCK2             0.966    0.038   25.559    0.000    0.791    0.791
##     TPCK3             0.955    0.042   22.563    0.000    0.782    0.782
##     TPCK4             1.017    0.040   25.160    0.000    0.832    0.832
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .TPK3 ~~
##    .TPK4              0.235    0.035    6.786    0.000    0.235    0.482
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .TCK1              0.000                               0.000    0.000
##    .TCK2              0.000                               0.000    0.000
##    .TPK1              0.000                               0.000    0.000
##    .TPK2              0.000                               0.000    0.000
##    .TPK3              0.000                               0.000    0.000
##    .TPK4              0.000                               0.000    0.000
##    .TPCK1             0.000                               0.000    0.000
##    .TPCK2             0.000                               0.000    0.000
##    .TPCK3             0.000                               0.000    0.000
##    .TPCK4             0.000                               0.000    0.000
##     gTPACK            0.000                               0.000    0.000
##
## Thresholds:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     TCK1|t1          -1.729    0.153  -11.295    0.000   -1.729   -1.729
##     TCK1|t2          -1.002    0.103   -9.701    0.000   -1.002   -1.002
##     TCK1|t3          -0.586    0.091   -6.419    0.000   -0.586   -0.586
##     TCK1|t4           0.858    0.098    8.742    0.000    0.858    0.858
##     TCK2|t1          -1.591    0.139  -11.409    0.000   -1.591   -1.591
##     TCK2|t2          -0.928    0.101   -9.230    0.000   -0.928   -0.928
##     TCK2|t3          -0.572    0.091   -6.286    0.000   -0.572   -0.572
##     TCK2|t4           0.686    0.093    7.339    0.000    0.686    0.686
##     TPK1|t1          -1.729    0.153  -11.295    0.000   -1.729   -1.729
##     TPK1|t2          -1.062    0.106  -10.039    0.000   -1.062   -1.062
##     TPK1|t3          -0.478    0.089   -5.352    0.000   -0.478   -0.478
##     TPK1|t4           0.928    0.101    9.230    0.000    0.928    0.928
##     TPK2|t1          -1.591    0.139  -11.409    0.000   -1.591   -1.591
##     TPK2|t2          -0.875    0.099   -8.865    0.000   -0.875   -0.875
##     TPK2|t3          -0.278    0.087   -3.194    0.001   -0.278   -0.278
##     TPK2|t4           1.002    0.103    9.701    0.000    1.002    1.002
##     TPK3|t1          -1.411    0.125  -11.274    0.000   -1.411   -1.411
```

```
##     TPK3|t2          -0.586    0.091   -6.419    0.000   -0.586   -0.586
##     TPK3|t3           0.182    0.086    2.108    0.035    0.182    0.182
##     TPK3|t4           1.513    0.133   11.391    0.000    1.513    1.513
##     TPK4|t1          -1.551    0.136  -11.408    0.000   -1.551   -1.551
##     TPK4|t2          -0.642    0.092   -6.946    0.000   -0.642   -0.642
##     TPK4|t3           0.064    0.086    0.748    0.454    0.064    0.064
##     TPK4|t4           1.351    0.121   11.153    0.000    1.351    1.351
##     TPCK1|t1         -1.551    0.136  -11.408    0.000   -1.551   -1.551
##     TPCK1|t2         -0.642    0.092   -6.946    0.000   -0.642   -0.642
##     TPCK1|t3          0.041    0.086    0.476    0.634    0.041    0.041
##     TPCK1|t4          1.351    0.121   11.153    0.000    1.351    1.351
##     TPCK2|t1         -1.444    0.127  -11.323    0.000   -1.444   -1.444
##     TPCK2|t2         -0.388    0.088   -4.411    0.000   -0.388   -0.388
##     TPCK2|t3          0.241    0.087    2.787    0.005    0.241    0.241
##     TPCK2|t4          1.351    0.121   11.153    0.000    1.351    1.351
##     TPCK3|t1         -1.591    0.139  -11.409    0.000   -1.591   -1.591
##     TPCK3|t2         -0.809    0.097   -8.366    0.000   -0.809   -0.809
##     TPCK3|t3         -0.158    0.086   -1.836    0.066   -0.158   -0.158
##     TPCK3|t4          0.983    0.103    9.585    0.000    0.983    0.983
##     TPCK4|t1         -1.444    0.127  -11.323    0.000   -1.444   -1.444
##     TPCK4|t2         -0.761    0.095   -7.985    0.000   -0.761   -0.761
##     TPCK4|t3          0.006    0.086    0.068    0.946    0.006    0.006
##     TPCK4|t4          1.268    0.116   10.926    0.000    1.268    1.268
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .TCK1              0.330                              0.330    0.330
##    .TCK2              0.255                              0.255    0.255
##    .TPK1              0.221                              0.221    0.221
##    .TPK2              0.179                              0.179    0.179
##    .TPK3              0.451                              0.451    0.451
##    .TPK4              0.526                              0.526    0.526
##    .TPCK1             0.275                              0.275    0.275
##    .TPCK2             0.375                              0.375    0.375
##    .TPCK3             0.389                              0.389    0.389
##    .TPCK4             0.307                              0.307    0.307
##     gTPACK            0.670    0.046   14.629    0.000    1.000    1.000
##
## Scales y*:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     TCK1              1.000                              1.000    1.000
##     TCK2              1.000                              1.000    1.000
##     TPK1              1.000                              1.000    1.000
##     TPK2              1.000                              1.000    1.000
##     TPK3              1.000                              1.000    1.000
##     TPK4              1.000                              1.000    1.000
##     TPCK1             1.000                              1.000    1.000
##     TPCK2             1.000                              1.000    1.000
##     TPCK3             1.000                              1.000    1.000
##     TPCK4             1.000                              1.000    1.000
##
## R-Square:
##                    Estimate
##     TCK1              0.670
```

```
##     TCK2              0.745
##     TPK1              0.779
##     TPK2              0.821
##     TPK3              0.549
##     TPK4              0.474
##     TPCK1             0.725
##     TPCK2             0.625
##     TPCK3             0.611
##     TPCK4             0.693
```

```
## Parameter estimates
parameterEstimates(tpack.cfa1.fitc)
```

```
##       lhs  op    rhs   est    se       z pvalue ci.lower ci.upper
## 1  gTPACK  =~   TCK1 1.000 0.000      NA     NA    1.000    1.000
## 2  gTPACK  =~   TCK2 1.055 0.035  30.536  0.000    0.987    1.122
## 3  gTPACK  =~   TPK1 1.078 0.040  26.689  0.000    0.999    1.158
## 4  gTPACK  =~   TPK2 1.107 0.038  29.259  0.000    1.033    1.181
## 5  gTPACK  =~   TPK3 0.905 0.039  23.060  0.000    0.828    0.982
## 6  gTPACK  =~   TPK4 0.841 0.046  18.178  0.000    0.750    0.932
## 7  gTPACK  =~  TPCK1 1.041 0.040  25.948  0.000    0.962    1.120
## 8  gTPACK  =~  TPCK2 0.966 0.038  25.559  0.000    0.892    1.040
## 9  gTPACK  =~  TPCK3 0.955 0.042  22.563  0.000    0.872    1.038
## 10 gTPACK  =~  TPCK4 1.017 0.040  25.160  0.000    0.938    1.097
## 11   TPK3  ~~   TPK4 0.235 0.035   6.786  0.000    0.167    0.303
## 12   TCK1   |     t1 -1.729 0.153 -11.295  0.000   -2.030   -1.429
## 13   TCK1   |     t2 -1.002 0.103  -9.701  0.000   -1.205   -0.800
## 14   TCK1   |     t3 -0.586 0.091  -6.419  0.000   -0.764   -0.407
## 15   TCK1   |     t4  0.858 0.098   8.742  0.000    0.666    1.051
## 16   TCK2   |     t1 -1.591 0.139 -11.409  0.000   -1.864   -1.318
## 17   TCK2   |     t2 -0.928 0.101  -9.230  0.000   -1.125   -0.731
## 18   TCK2   |     t3 -0.572 0.091  -6.286  0.000   -0.750   -0.394
## 19   TCK2   |     t4  0.686 0.093   7.339  0.000    0.502    0.869
## 20   TPK1   |     t1 -1.729 0.153 -11.295  0.000   -2.030   -1.429
## 21   TPK1   |     t2 -1.062 0.106 -10.039  0.000   -1.269   -0.854
## 22   TPK1   |     t3 -0.478 0.089  -5.352  0.000   -0.653   -0.303
## 23   TPK1   |     t4  0.928 0.101   9.230  0.000    0.731    1.125
## 24   TPK2   |     t1 -1.591 0.139 -11.409  0.000   -1.864   -1.318
## 25   TPK2   |     t2 -0.875 0.099  -8.865  0.000   -1.069   -0.682
## 26   TPK2   |     t3 -0.278 0.087  -3.194  0.001   -0.448   -0.107
## 27   TPK2   |     t4  1.002 0.103   9.701  0.000    0.800    1.205
## 28   TPK3   |     t1 -1.411 0.125 -11.274  0.000   -1.657   -1.166
## 29   TPK3   |     t2 -0.586 0.091  -6.419  0.000   -0.764   -0.407
## 30   TPK3   |     t3  0.182 0.086   2.108  0.035    0.013    0.351
## 31   TPK3   |     t4  1.513 0.133  11.391  0.000    1.253    1.774
## 32   TPK4   |     t1 -1.551 0.136 -11.408  0.000   -1.817   -1.284
## 33   TPK4   |     t2 -0.642 0.092  -6.946  0.000   -0.823   -0.461
## 34   TPK4   |     t3  0.064 0.086   0.748  0.454   -0.104    0.232
## 35   TPK4   |     t4  1.351 0.121  11.153  0.000    1.113    1.588
## 36  TPCK1   |     t1 -1.551 0.136 -11.408  0.000   -1.817   -1.284
## 37  TPCK1   |     t2 -0.642 0.092  -6.946  0.000   -0.823   -0.461
## 38  TPCK1   |     t3  0.041 0.086   0.476  0.634   -0.127    0.209
## 39  TPCK1   |     t4  1.351 0.121  11.153  0.000    1.113    1.588
## 40  TPCK2   |     t1 -1.444 0.127 -11.323  0.000   -1.694   -1.194
## 41  TPCK2   |     t2 -0.388 0.088  -4.411  0.000   -0.561   -0.216
```

```
## 42  TPCK2   |     t3  0.241 0.087   2.787  0.005    0.072    0.411
## 43  TPCK2   |     t4  1.351 0.121  11.153  0.000    1.113    1.588
## 44  TPCK3   |     t1 -1.591 0.139 -11.409  0.000   -1.864   -1.318
## 45  TPCK3   |     t2 -0.809 0.097  -8.366  0.000   -0.998   -0.619
## 46  TPCK3   |     t3 -0.158 0.086  -1.836  0.066   -0.327    0.011
## 47  TPCK3   |     t4  0.983 0.103   9.585  0.000    0.782    1.184
## 48  TPCK4   |     t1 -1.444 0.127 -11.323  0.000   -1.694   -1.194
## 49  TPCK4   |     t2 -0.761 0.095  -7.985  0.000   -0.948   -0.574
## 50  TPCK4   |     t3  0.006 0.086   0.068  0.946   -0.162    0.174
## 51  TPCK4   |     t4  1.268 0.116  10.926  0.000    1.041    1.496
## 52   TCK1  ~~   TCK1  0.330 0.000      NA     NA    0.330    0.330
## 53   TCK2  ~~   TCK2  0.255 0.000      NA     NA    0.255    0.255
## 54   TPK1  ~~   TPK1  0.221 0.000      NA     NA    0.221    0.221
## 55   TPK2  ~~   TPK2  0.179 0.000      NA     NA    0.179    0.179
## 56   TPK3  ~~   TPK3  0.451 0.000      NA     NA    0.451    0.451
## 57   TPK4  ~~   TPK4  0.526 0.000      NA     NA    0.526    0.526
## 58  TPCK1  ~~  TPCK1  0.275 0.000      NA     NA    0.275    0.275
## 59  TPCK2  ~~  TPCK2  0.375 0.000      NA     NA    0.375    0.375
## 60  TPCK3  ~~  TPCK3  0.389 0.000      NA     NA    0.389    0.389
## 61  TPCK4  ~~  TPCK4  0.307 0.000      NA     NA    0.307    0.307
## 62 gTPACK  ~~ gTPACK  0.670 0.046  14.629  0.000    0.580    0.759
## 63   TCK1 ~*~   TCK1  1.000 0.000      NA     NA    1.000    1.000
## 64   TCK2 ~*~   TCK2  1.000 0.000      NA     NA    1.000    1.000
## 65   TPK1 ~*~   TPK1  1.000 0.000      NA     NA    1.000    1.000
## 66   TPK2 ~*~   TPK2  1.000 0.000      NA     NA    1.000    1.000
## 67   TPK3 ~*~   TPK3  1.000 0.000      NA     NA    1.000    1.000
## 68   TPK4 ~*~   TPK4  1.000 0.000      NA     NA    1.000    1.000
## 69  TPCK1 ~*~  TPCK1  1.000 0.000      NA     NA    1.000    1.000
## 70  TPCK2 ~*~  TPCK2  1.000 0.000      NA     NA    1.000    1.000
## 71  TPCK3 ~*~  TPCK3  1.000 0.000      NA     NA    1.000    1.000
## 72  TPCK4 ~*~  TPCK4  1.000 0.000      NA     NA    1.000    1.000
## 73   TCK1  ~1         0.000 0.000      NA     NA    0.000    0.000
## 74   TCK2  ~1         0.000 0.000      NA     NA    0.000    0.000
## 75   TPK1  ~1         0.000 0.000      NA     NA    0.000    0.000
## 76   TPK2  ~1         0.000 0.000      NA     NA    0.000    0.000
## 77   TPK3  ~1         0.000 0.000      NA     NA    0.000    0.000
## 78   TPK4  ~1         0.000 0.000      NA     NA    0.000    0.000
## 79  TPCK1  ~1         0.000 0.000      NA     NA    0.000    0.000
## 80  TPCK2  ~1         0.000 0.000      NA     NA    0.000    0.000
## 81  TPCK3  ~1         0.000 0.000      NA     NA    0.000    0.000
## 82  TPCK4  ~1         0.000 0.000      NA     NA    0.000    0.000
## 83 gTPACK  ~1         0.000 0.000      NA     NA    0.000    0.000
```

```
## Standardized residuals
resid(tpack.cfa1.fitc, type="standardized")
```

```
## $type
## [1] "standardized"
##
## $cov
##       TCK1   TCK2   TPK1   TPK2   TPK3   TPK4   TPCK1  TPCK2  TPCK3  TPCK4
## TCK1   0.000
## TCK2   1.172  0.000
## TPK1   1.027  1.701  0.000
## TPK2  -0.918  1.897  1.951  0.000
```

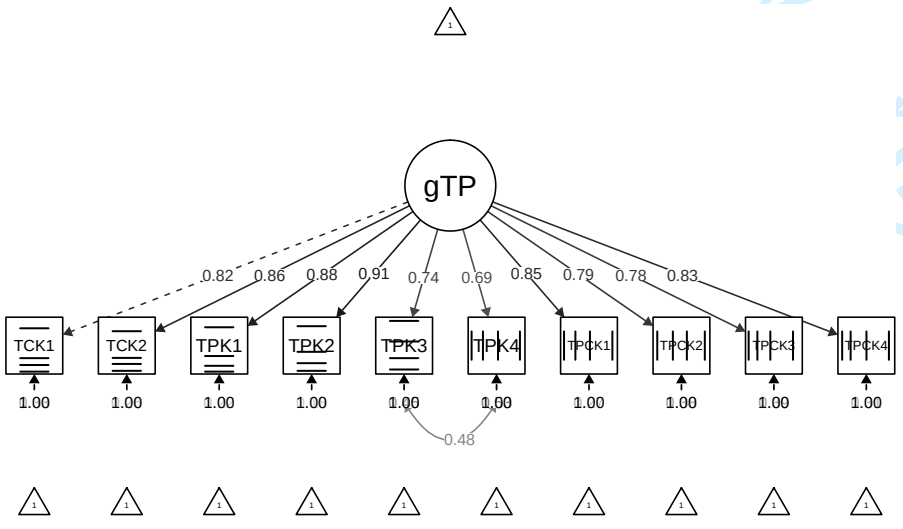
```
## TPK3  -0.274 -2.383 -1.675  0.387  0.000
## TPK4  -2.664 -2.797 -1.591  0.526  0.000  0.000
## TPCK1 -3.218 -1.387 -0.262 -4.422  2.778  3.319  0.000
## TPCK2 -0.620 -0.243 -4.215 -1.767  0.929  1.344  3.460  0.000
## TPCK3 -0.596 -0.219 -1.018  0.927 -1.752 -0.190 -0.298  0.692  0.000
## TPCK4  3.250 -1.797 -0.069 -0.538  0.619 -0.389 -2.093 -1.438  1.494  0.000
##
## $mean
##  TCK1  TCK2  TPK1  TPK2  TPK3  TPK4 TPCK1 TPCK2 TPCK3 TPCK4  <NA>  <NA>  <NA>
##     0     0     0     0     0     0     0     0     0     0    NA    NA    NA
##  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>
##    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
##  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>  <NA>
##    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
##  <NA>
##    NA
##
## $th
##  TCK1|t1  TCK1|t2  TCK1|t3  TCK1|t4  TCK2|t1  TCK2|t2  TCK2|t3  TCK2|t4
##        0        0        0        0        0        0        0        0
##  TPK1|t1  TPK1|t2  TPK1|t3  TPK1|t4  TPK2|t1  TPK2|t2  TPK2|t3  TPK2|t4
##        0        0        0        0        0        0        0        0
##  TPK3|t1  TPK3|t2  TPK3|t3  TPK3|t4  TPK4|t1  TPK4|t2  TPK4|t3  TPK4|t4
##        0        0        0        0        0        0        0        0
## TPCK1|t1 TPCK1|t2 TPCK1|t3 TPCK1|t4 TPCK2|t1 TPCK2|t2 TPCK2|t3 TPCK2|t4
##        0        0        0        0        0        0        0        0
## TPCK3|t1 TPCK3|t2 TPCK3|t3 TPCK3|t4 TPCK4|t1 TPCK4|t2 TPCK4|t3 TPCK4|t4
##        0        0        0        0        0        0        0        0
```

```
## Modification indices
modindices(tpack.cfa1.fitc)
```

```
##       lhs op   rhs    mi    epc sepc.lv sepc.all sepc.nox
## 84   TCK1 ~~  TCK2 0.777  0.037   0.037    0.129    0.129
## 85   TCK1 ~~  TPK1 0.397  0.027   0.027    0.099    0.099
## 86   TCK1 ~~  TPK2 0.291 -0.022  -0.022   -0.091   -0.091
## 87   TCK1 ~~  TPK3 0.042 -0.011  -0.011   -0.028   -0.028
## 88   TCK1 ~~  TPK4 2.963 -0.112  -0.112   -0.267   -0.267
## 89   TCK1 ~~ TPCK1 3.802 -0.104  -0.104   -0.345   -0.345
## 90   TCK1 ~~ TPCK2 0.193 -0.023  -0.023   -0.067   -0.067
## 91   TCK1 ~~ TPCK3 0.132 -0.019  -0.019   -0.054   -0.054
## 92   TCK1 ~~ TPCK4 5.031  0.093   0.093    0.292    0.292
## 93   TCK2 ~~  TPK1 1.636  0.045   0.045    0.190    0.190
## 94   TCK2 ~~  TPK2 1.475  0.043   0.043    0.202    0.202
## 95   TCK2 ~~  TPK3 1.804 -0.069  -0.069   -0.203   -0.203
## 96   TCK2 ~~  TPK4 2.739 -0.096  -0.096   -0.261   -0.261
## 97   TCK2 ~~ TPCK1 0.647 -0.033  -0.033   -0.126   -0.126
## 98   TCK2 ~~ TPCK2 0.026 -0.008  -0.008   -0.025   -0.025
## 99   TCK2 ~~ TPCK3 0.018 -0.006  -0.006   -0.020   -0.020
## 100  TCK2 ~~ TPCK4 1.176 -0.051  -0.051   -0.180   -0.180
## 101  TPK1 ~~  TPK2 1.609  0.047   0.047    0.238    0.238
## 102  TPK1 ~~  TPK3 0.868 -0.046  -0.046   -0.146   -0.146
## 103  TPK1 ~~  TPK4 1.014 -0.058  -0.058   -0.169   -0.169
## 104  TPK1 ~~ TPCK1 0.027 -0.007  -0.007   -0.028   -0.028
## 105  TPK1 ~~ TPCK2 5.188 -0.117  -0.117   -0.405   -0.405
```

```
## 106  TPK1 ~~ TPCK3 0.290 -0.025  -0.025   -0.085   -0.085
## 107  TPK1 ~~ TPCK4 0.001 -0.001  -0.001   -0.005   -0.005
## 108  TPK2 ~~  TPK3 0.067  0.012   0.012    0.043    0.043
## 109  TPK2 ~~  TPK4 0.102  0.017   0.017    0.054    0.054
## 110  TPK2 ~~ TPCK1 4.910 -0.098  -0.098   -0.440   -0.440
## 111  TPK2 ~~ TPCK2 1.125 -0.050  -0.050   -0.191   -0.191
## 112  TPK2 ~~ TPCK3 0.308  0.023   0.023    0.089    0.089
## 113  TPK2 ~~ TPCK4 0.115 -0.015  -0.015   -0.063   -0.063
## 114  TPK3 ~~ TPCK1 3.724  0.088   0.088    0.250    0.250
## 115  TPK3 ~~ TPCK2 0.427  0.033   0.033    0.080    0.080
## 116  TPK3 ~~ TPCK3 1.248 -0.064  -0.064   -0.153   -0.153
## 117  TPK3 ~~ TPCK4 0.135  0.018   0.018    0.047    0.047
## 118  TPK4 ~~ TPCK1 6.013  0.108   0.108    0.284    0.284
## 119  TPK4 ~~ TPCK2 0.848  0.046   0.046    0.104    0.104
## 120  TPK4 ~~ TPCK3 0.014 -0.006  -0.006   -0.014   -0.014
## 121  TPK4 ~~ TPCK4 0.062 -0.014  -0.014   -0.035   -0.035
## 122 TPCK1 ~~ TPCK2 6.332  0.100   0.100    0.311    0.311
## 123 TPCK1 ~~ TPCK3 0.049 -0.011  -0.011   -0.033   -0.033
## 124 TPCK1 ~~ TPCK4 1.303 -0.053  -0.053   -0.183   -0.183
## 125 TPCK2 ~~ TPCK3 0.278  0.025   0.025    0.066    0.066
## 126 TPCK2 ~~ TPCK4 0.880 -0.047  -0.047   -0.140   -0.140
## 127 TPCK3 ~~ TPCK4 0.883  0.042   0.042    0.121    0.121
```

```r
# Visualize the path model
semPaths(tpack.cfa1.fitc,
         rotation = 1,
         layout = "tree2",
         what = "std",
         posCol = "black",
         edge.width = 0.5,
         style = "Lisrel",
         fade = T,
         edge.label.position = 0.55)
```



Conclusion Accept the model with robust ML estimation, one general TPACK self-efficacy factor (`gTPACK`) and several residual covariances. Model `tpack.nfm` is the final model.

```
## Extract the factor scores
tpack.sf <- lavPredict(tpack.nfm.fit)
head(tpack.sf, 5)
```

```
##          gTPACK
## [1,] -0.5516057
## [2,]  0.9724480
## [3,]  0.3589668
## [4,] -2.0989683
## [5,]  0.4081004
```

```
## Check by correlating with the sum score
## Define the sum score
tpack.sum <- tpack$TCK1+
  tpack$TCK2+
  tpack$TPK1+
  tpack$TPK2+
  tpack$TPK3+
  tpack$TPK4+
  tpack$TPCK1+
  tpack$TPCK2+
  tpack$TPCK3+
  tpack$TPCK4

tpack.temp <- data.frame(tpack.sum, tpack.sf)

## Correlation
cor(tpack.temp, use = "pairwise.complete.obs")
```

```
##           tpack.sum    gTPACK
## tpack.sum 1.0000000 0.9868684
## gTPACK    0.9868684 1.0000000
```

```
## Add the new factor score to the dataset
covid19otlc.tpe$gTPACK <- lavPredict(tpack.nfm.fit)[,c("gTPACK")]
```

Perceived institutional support

```
############################################################
## Select the data
pis.var <- c("UNPERSID", "PIS1", "PIS2", "PIS3",
             "PIS4", "PIS5", "PIS6")
# Subset the data
pis <- covid19otlc.tpe[pis.var]
head(pis, 5)
```

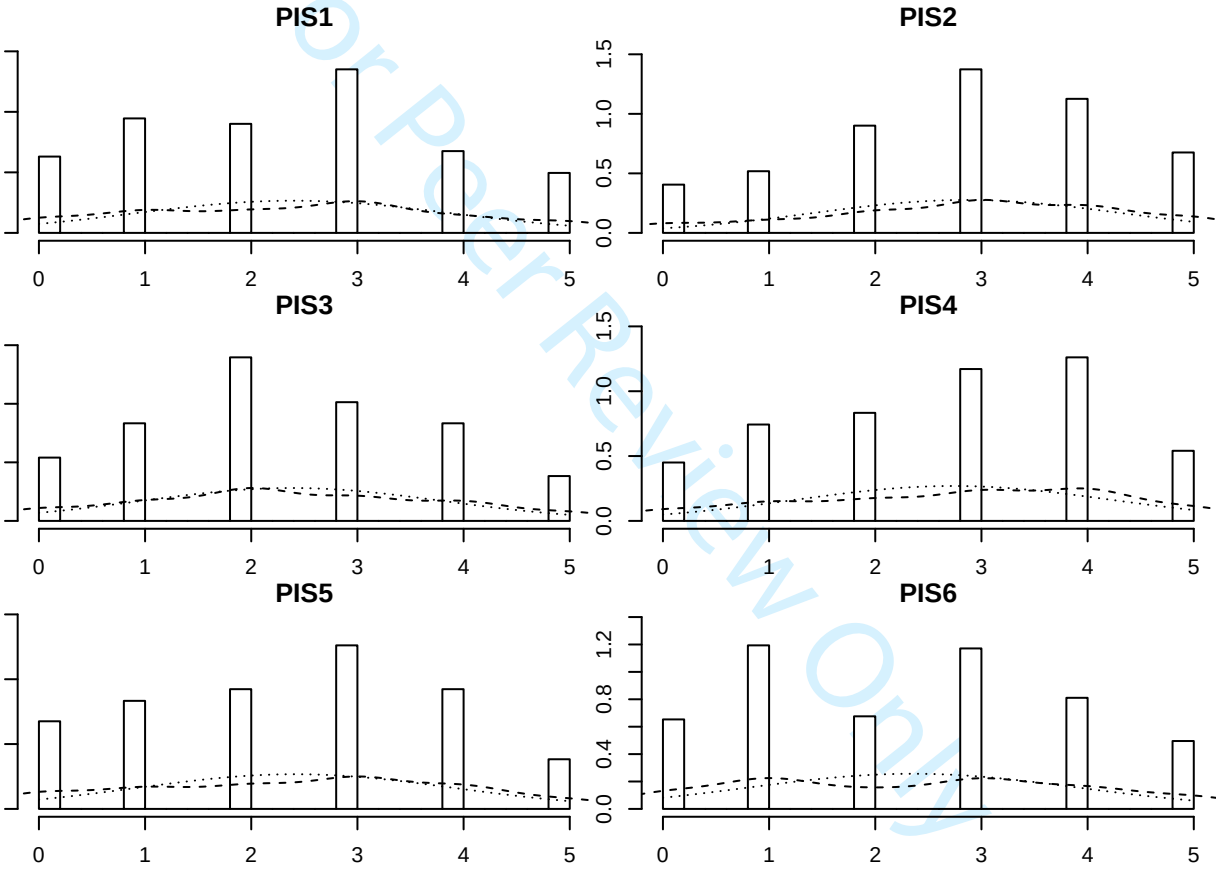
Descriptive scale statistics and correlation matrix

```
##   UNPERSID PIS1 PIS2 PIS3 PIS4 PIS5 PIS6
## 1     4030    2    0    1    2    1    0
## 2     4312    2    2    2    1    0    0
## 3     4026    3    3    3    3    2    3
## 4     4028    3    4    4    4    2    4
## 5     4032    2    3    2    3    2    2
```

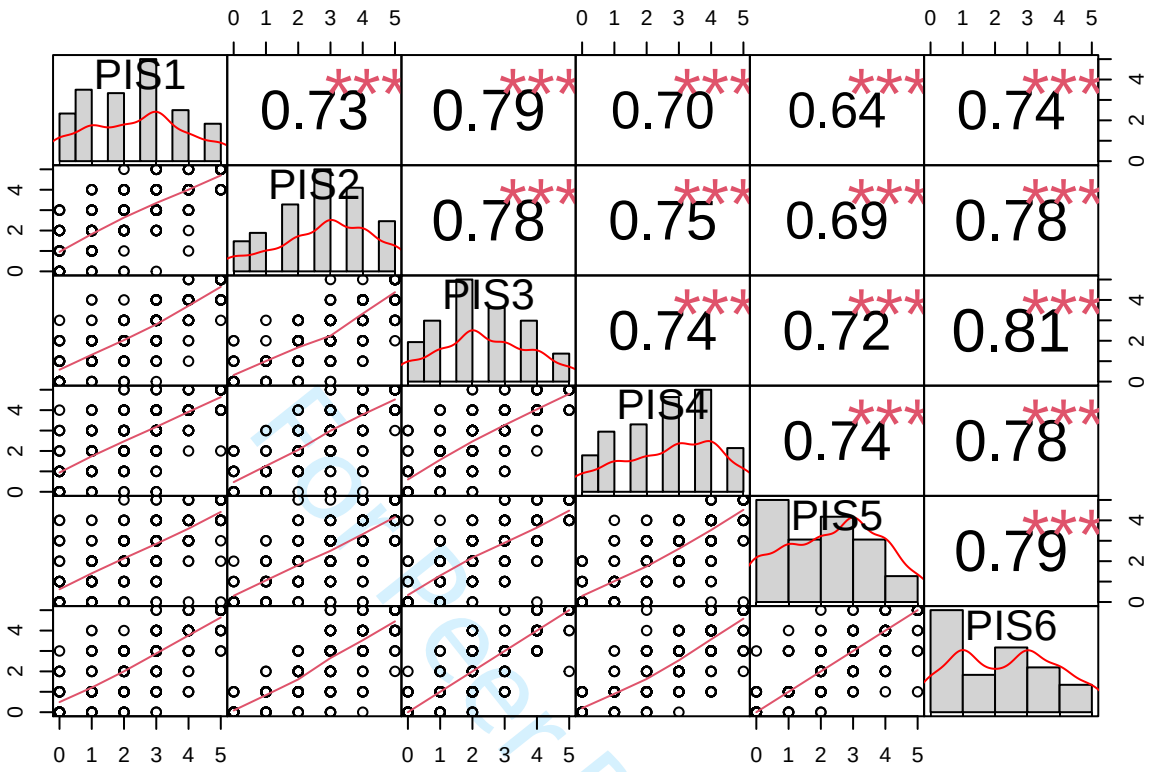
```
#############################################################
## Descriptive statistics
describe(pis[,-1])
```

```
##      vars   n mean   sd median trimmed  mad min max range  skew kurtosis  se
## PIS1    1 222 2.40 1.50      3    2.37 1.48   0   5     5  0.03    -0.95 0.1
## PIS2    2 222 2.86 1.44      3    2.93 1.48   0   5     5 -0.35    -0.69 0.1
## PIS3    3 222 2.38 1.42      2    2.38 1.48   0   5     5  0.07    -0.83 0.1
## PIS4    4 222 2.73 1.48      3    2.78 1.48   0   5     5 -0.28    -0.94 0.1
## PIS5    5 222 2.41 1.49      3    2.42 1.48   0   5     5 -0.08    -1.00 0.1
## PIS6    6 222 2.36 1.56      2    2.32 1.48   0   5     5  0.08    -1.14 0.1
```

```
## Distributions
multi.hist(pis[,-1], density = TRUE)
```




```
## Correlation chart
chart.Correlation(pis[,-1], method = c("pearson"))
```




```
############################################################
## Correlation matrix
## APA format
apa.cor.table(pis[,-1], filename="Table_PIS.doc", table.number=2)
```

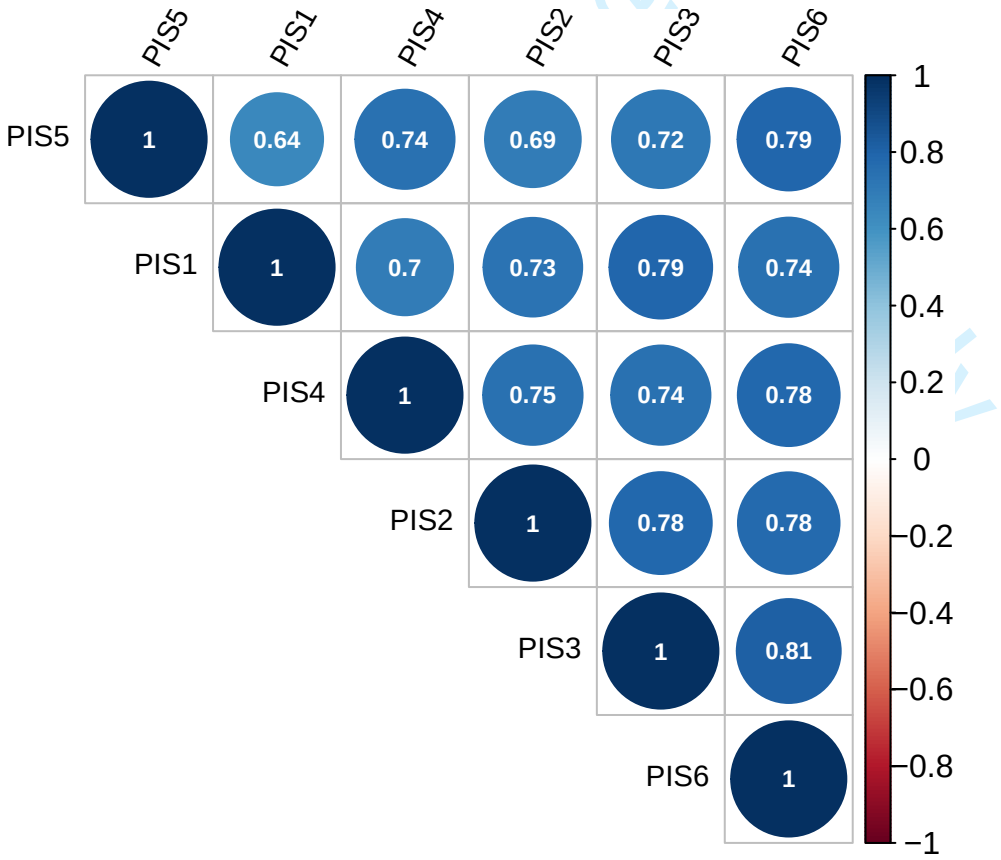
```
##
##
## Table 2
##
## Means, standard deviations, and correlations with confidence intervals
##
##
##   Variable M    SD   1          2          3          4          5
##   1. PIS1  2.40 1.50
##
##   2. PIS2  2.86 1.44 .73**
##                       [.67, .79]
##
##   3. PIS3  2.38 1.42 .79**      .78**
##                       [.74, .84] [.73, .83]
##
##   4. PIS4  2.73 1.48 .70**      .75**      .74**
##                       [.62, .76] [.68, .80] [.68, .80]
##
##   5. PIS5  2.41 1.49 .64**      .69**      .72**      .74**
##                       [.56, .71] [.61, .75] [.65, .78] [.68, .80]
##
##   6. PIS6  2.36 1.56 .74**      .78**      .81**      .78**      .79**
##                       [.68, .80] [.72, .82] [.76, .85] [.72, .83] [.73, .83]
##
```

```
##
## Note. M and SD are used to represent mean and standard deviation, respectively.
## Values in square brackets indicate the 95% confidence interval.
## The confidence interval is a plausible range of population correlations
## that could have caused the sample correlation (Cumming, 2014).
## * indicates p < .05. ** indicates p < .01.
##
```

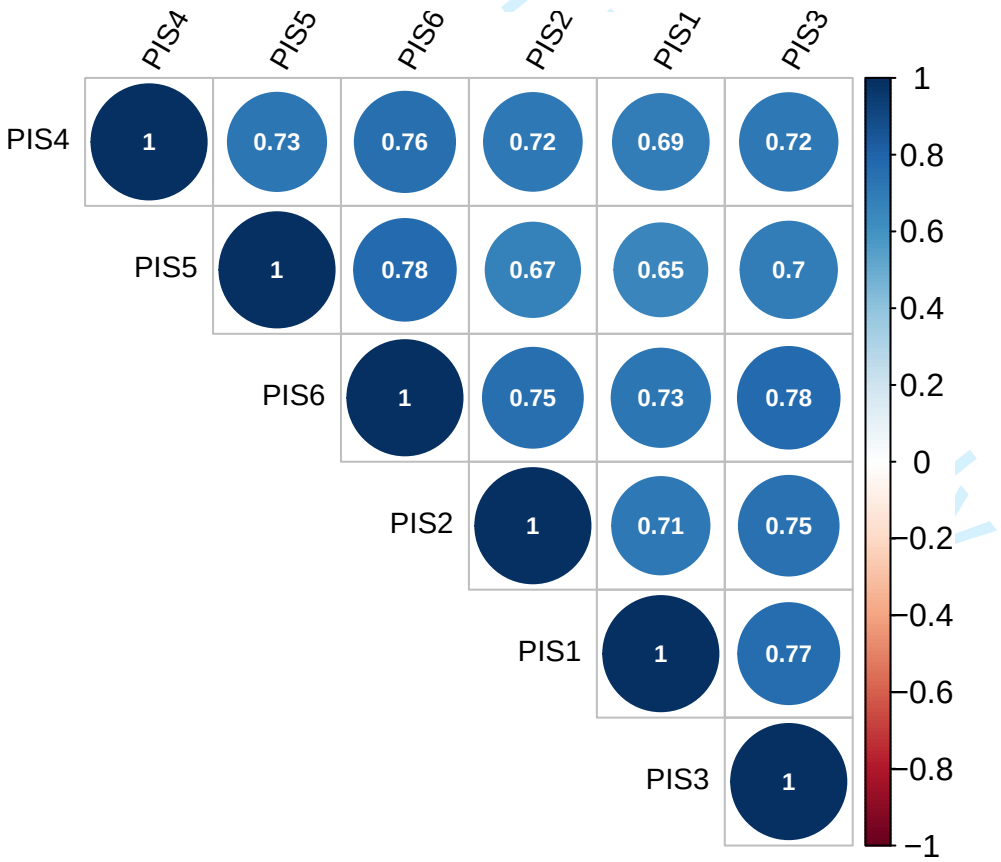
```
## Extract the Pearson correlation matrix
pis.cor <- cor(pis[,-1], method = "pearson",
               use = "pairwise.complete.obs")
pis.cor
```

```
##           PIS1      PIS2      PIS3      PIS4      PIS5      PIS6
## PIS1 1.0000000 0.7338217 0.7945276 0.6970668 0.6401190 0.7421310
## PIS2 0.7338217 1.0000000 0.7822714 0.7450898 0.6905033 0.7775667
## PIS3 0.7945276 0.7822714 1.0000000 0.7424350 0.7186606 0.8139405
## PIS4 0.6970668 0.7450898 0.7424350 1.0000000 0.7418357 0.7811474
## PIS5 0.6401190 0.6905033 0.7186606 0.7418357 1.0000000 0.7900909
## PIS6 0.7421310 0.7775667 0.8139405 0.7811474 0.7900909 1.0000000
```

```
## Correlogram
corrplot(pis.cor, type = "upper", order = "hclust",
         tl.col = "black", tl.srt = 60,
         addCoef.col = "white",
         number.cex = 0.75,
         cl.cex = 1,
         tl.cex = 0.9)
```



```
## Extract the polychoric correlation matrix
pis.pcor <- polychoric(pis[,-1])

## Warning in matpLower(x, nvar, gminx, gmaxx, gminy, gmaxy): 15 cells were
## adjusted for 0 values using the correction for continuity. Examine your data
## carefully.
pis.pcor$rho

##           PIS1      PIS2      PIS3      PIS4      PIS5      PIS6
## PIS1 1.0000000 0.7134438 0.7693800 0.6902077 0.6506381 0.7279092
## PIS2 0.7134438 1.0000000 0.7488392 0.7197437 0.6703412 0.7517822
## PIS3 0.7693800 0.7488392 1.0000000 0.7153792 0.6997897 0.7783809
## PIS4 0.6902077 0.7197437 0.7153792 1.0000000 0.7268357 0.7571224
## PIS5 0.6506381 0.6703412 0.6997897 0.7268357 1.0000000 0.7785224
## PIS6 0.7279092 0.7517822 0.7783809 0.7571224 0.7785224 1.0000000
## Correlogram
corrplot(pis.pcor$rho, type = "upper", order = "hclust",
         tl.col = "black", tl.srt = 60,
         addCoef.col = "white",
         number.cex = 0.75,
         cl.cex = 1,
         tl.cex = 0.9)
```



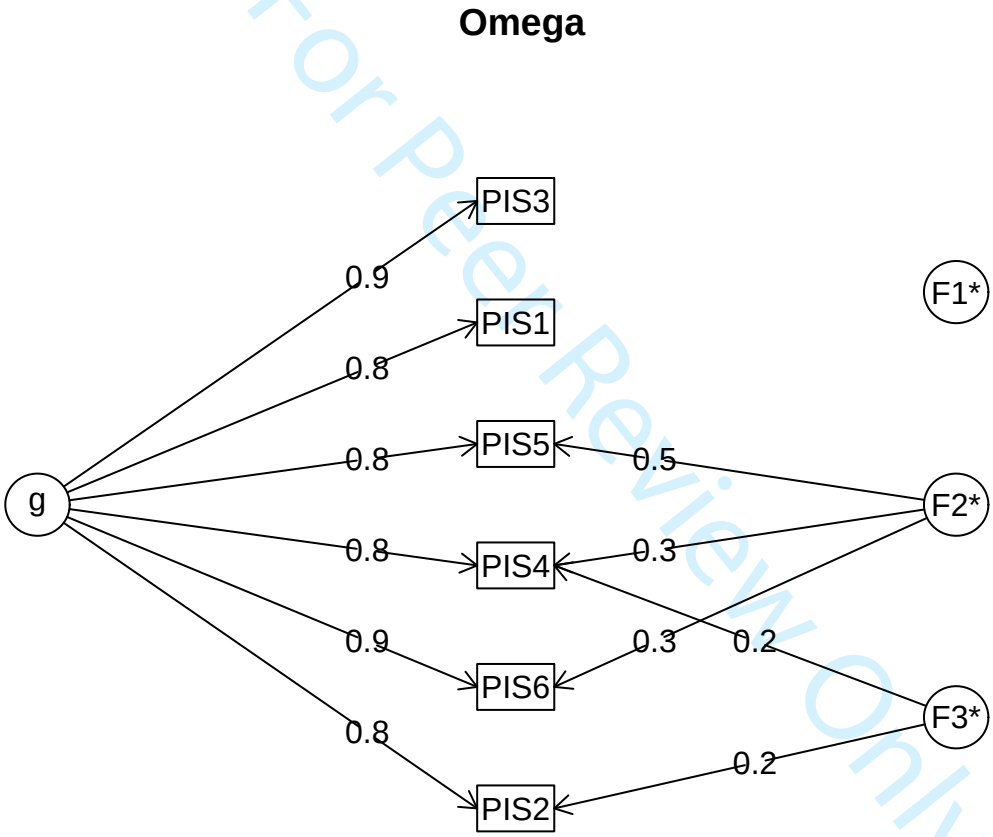

```
## Absolute difference between the two matrices
pis.pcor$rho-pis.cor

##              PIS1         PIS2         PIS3         PIS4         PIS5         PIS6
```

```
## PIS1  0.000000000 -0.02037793 -0.02514756 -0.006859127  0.01051904 -0.01422170
## PIS2 -0.020377933  0.00000000 -0.03343218 -0.025346068 -0.02016215 -0.02578455
## PIS3 -0.025147565 -0.03343218  0.00000000 -0.027055855 -0.01887089 -0.03555957
## PIS4 -0.006859127 -0.02534607 -0.02705586  0.000000000 -0.01500002 -0.02402491
## PIS5  0.010519038 -0.02016215 -0.01887089 -0.015000024  0.00000000 -0.01156849
## PIS6 -0.014221702 -0.02578455 -0.03555957 -0.024024907 -0.01156849  0.00000000
```

```
max(pis.pcor$rho-pis.cor)
```

```
## [1] 0.01051904
```

```
#############################################################
## Reliability coefficients (overall scale)
omega(pis[,-1])
```




```
## Omega
## Call: omegah(m = m, nfactors = nfactors, fm = fm, key = key, flip = flip,
##     digits = digits, title = title, sl = sl, labels = labels,
##     plot = plot, n.obs = n.obs, rotate = rotate, Phi = Phi, option = option,
##     covar = covar)
## Alpha:                 0.95
## G.6:                   0.94
## Omega Hierarchical:    0.89
## Omega H asymptotic:    0.93
## Omega Total            0.96
##
## Schmid Leiman Factor loadings greater than  0.2
##         g  F1*  F2*   F3*   h2   u2   p2
## PIS1 0.83                0.72 0.28 0.95
```

```
## PIS2 0.83            0.23 0.77 0.23 0.90
## PIS3 0.93 0.20            0.91 0.09 0.95
## PIS4 0.80      0.27  0.20 0.75 0.25 0.85
## PIS5 0.77      0.50       0.84 0.16 0.70
## PIS6 0.86      0.26       0.83 0.17 0.90
##
## With eigenvalues of:
##    g  F1*  F2*  F3*
## 4.22 0.07 0.41 0.13
##
## general/max  10.37   max/min =   5.88
## mean percent general =  0.88    with sd =  0.09 and cv of  0.11
## Explained Common Variance of the general factor =  0.87
##
## The degrees of freedom are 0  and the fit is  0
## The number of observations was  222  with Chi Square =  0  with prob <  NA
## The root mean square of the residuals is  0
## The df corrected root mean square of the residuals is  NA
##
## Compare this with the adequacy of just a general factor and no group factors
## The degrees of freedom for just the general factor are 9  and the fit is  0.27
## The number of observations was  222  with Chi Square =  58.99  with prob <  2.1e-09
## The root mean square of the residuals is  0.06
## The df corrected root mean square of the residuals is  0.08
##
## RMSEA index =  0.158  and the 10 % confidence intervals are  0.121 0.198
## BIC =  10.37
##
## Measures of factor score adequacy
##                                                 g   F1*  F2*   F3*
## Correlation of scores with factors            0.96  0.31 0.74  0.54
## Multiple R square of scores with factors      0.92  0.10 0.55  0.30
## Minimum correlation of factor score estimates 0.84 -0.81 0.10 -0.41
##
##  Total, General and Subset omega for each subset
##                                                    g  F1*  F2*  F3*
## Omega total for total scores and subscales    0.96 0.90 0.91 0.75
## Omega general for total scores and subscales  0.89 0.86 0.77 0.69
## Omega group for total scores and subscales    0.04 0.03 0.14 0.05
#############################################################
```

```
## Model specification
## One factor
pis.cfa1 <- '
             # PIS general factor
             gPIS =~ PIS1+PIS2+PIS3+PIS4+PIS5+PIS6
'

## Model estimation
pis.cfa1.fit <- sem(pis.cfa1, data = pis[,-1],
                    missing = "FIML",
                    estimator = "MLR",
```

```
                      se="robust.mlr")

## Summary
summary(pis.cfa1.fit,
        rsquare = TRUE,
        fit.measures = TRUE,
        standardized = TRUE)
```

Measurement model

```
## lavaan 0.6-6 ended normally after 20 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         18
##
##   Number of observations                           222
##   Number of missing patterns                         1
##
## Model Test User Model:
##                                                   Standard      Robust
##   Test Statistic                                    28.920      20.975
##   Degrees of freedom                                     9           9
##   P-value (Chi-square)                              0.001       0.013
##   Scaling correction factor                                     1.379
##         Yuan-Bentler correction (Mplus variant)
##
## Model Test Baseline Model:
##
##   Test statistic                                 1231.574     869.431
##   Degrees of freedom                                    15          15
##   P-value                                           0.000       0.000
##   Scaling correction factor                                     1.417
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                       0.984       0.986
##   Tucker-Lewis Index (TLI)                          0.973       0.977
##
##   Robust Comparative Fit Index (CFI)                            0.986
##   Robust Tucker-Lewis Index (TLI)                               0.977
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)                -1809.322   -1809.322
##   Scaling correction factor                                     1.007
##       for the MLR correction
##   Loglikelihood unrestricted model (H1)        -1794.862   -1794.862
##   Scaling correction factor                                     1.131
##       for the MLR correction
##
##   Akaike (AIC)                                  3654.644    3654.644
##   Bayesian (BIC)                                3715.892    3715.892
##   Sample-size adjusted Bayesian (BIC)           3658.848    3658.848
```

```
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.100       0.077
##   90 Percent confidence interval - lower         0.060       0.041
##   90 Percent confidence interval - upper         0.142       0.115
##   P-value RMSEA <= 0.05                          0.021       0.101
##
##   Robust RMSEA                                                0.091
##   90 Percent confidence interval - lower                      0.040
##   90 Percent confidence interval - upper                      0.142
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.019       0.019
##
## Parameter Estimates:
##
##   Standard errors                             Sandwich
##   Information bread                           Observed
##   Observed information based on                Hessian
##
## Latent Variables:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   gPIS =~
##     PIS1             1.000                               1.247    0.833
##     PIS2             0.996    0.057   17.548    0.000    1.241    0.863
##     PIS3             1.020    0.048   21.466    0.000    1.272    0.897
##     PIS4             1.012    0.057   17.667    0.000    1.261    0.853
##     PIS5             0.987    0.064   15.421    0.000    1.230    0.826
##     PIS6             1.136    0.057   19.956    0.000    1.416    0.912
##
## Intercepts:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .PIS1             2.396    0.100   23.861    0.000    2.396    1.601
##    .PIS2             2.865    0.097   29.655    0.000    2.865    1.990
##    .PIS3             2.383    0.095   25.036    0.000    2.383    1.680
##    .PIS4             2.734    0.099   27.553    0.000    2.734    1.849
##    .PIS5             2.414    0.100   24.168    0.000    2.414    1.622
##    .PIS6             2.356    0.104   22.614    0.000    2.356    1.518
##     gPIS             0.000                               0.000    0.000
##
## Variances:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .PIS1             0.685    0.089    7.709    0.000    0.685    0.306
##    .PIS2             0.531    0.067    7.926    0.000    0.531    0.256
##    .PIS3             0.392    0.054    7.312    0.000    0.392    0.195
##    .PIS4             0.595    0.073    8.179    0.000    0.595    0.272
##    .PIS5             0.702    0.101    6.963    0.000    0.702    0.317
##    .PIS6             0.403    0.057    7.022    0.000    0.403    0.167
##     gPIS             1.554    0.173    8.973    0.000    1.000    1.000
##
## R-Square:
##                   Estimate
```

```
##     PIS1              0.694
##     PIS2              0.744
##     PIS3              0.805
##     PIS4              0.728
##     PIS5              0.683
##     PIS6              0.833
```

```
## Parameter estimates
parameterEstimates(pis.cfa1.fit)
```

```
##     lhs op  rhs   est    se      z pvalue ci.lower ci.upper
## 1  gPIS =~ PIS1 1.000 0.000     NA     NA    1.000    1.000
## 2  gPIS =~ PIS2 0.996 0.057 17.548      0    0.885    1.107
## 3  gPIS =~ PIS3 1.020 0.048 21.466      0    0.927    1.114
## 4  gPIS =~ PIS4 1.012 0.057 17.667      0    0.899    1.124
## 5  gPIS =~ PIS5 0.987 0.064 15.421      0    0.861    1.112
## 6  gPIS =~ PIS6 1.136 0.057 19.956      0    1.024    1.248
## 7  PIS1 ~~ PIS1 0.685 0.089  7.709      0    0.511    0.859
## 8  PIS2 ~~ PIS2 0.531 0.067  7.926      0    0.399    0.662
## 9  PIS3 ~~ PIS3 0.392 0.054  7.312      0    0.287    0.498
## 10 PIS4 ~~ PIS4 0.595 0.073  8.179      0    0.453    0.738
## 11 PIS5 ~~ PIS5 0.702 0.101  6.963      0    0.505    0.900
## 12 PIS6 ~~ PIS6 0.403 0.057  7.022      0    0.291    0.516
## 13 gPIS ~~ gPIS 1.554 0.173  8.973      0    1.215    1.894
## 14 PIS1 ~1      2.396 0.100 23.861      0    2.200    2.593
## 15 PIS2 ~1      2.865 0.097 29.655      0    2.676    3.054
## 16 PIS3 ~1      2.383 0.095 25.036      0    2.196    2.569
## 17 PIS4 ~1      2.734 0.099 27.553      0    2.540    2.929
## 18 PIS5 ~1      2.414 0.100 24.168      0    2.219    2.610
## 19 PIS6 ~1      2.356 0.104 22.614      0    2.152    2.560
## 20 gPIS ~1      0.000 0.000     NA     NA    0.000    0.000
```

```
## Standardized residuals
resid(pis.cfa1.fit, type="standardized")
```

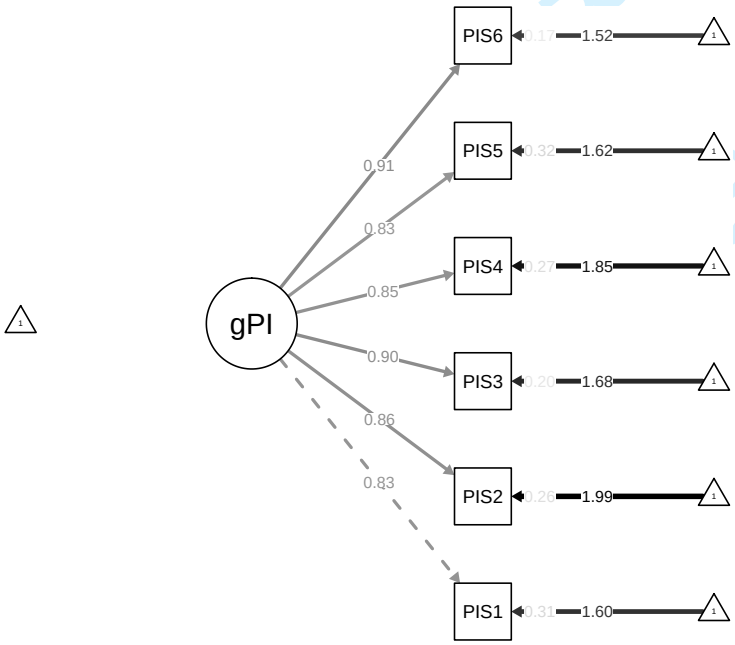
```
## $type
## [1] "standardized"
##
## $cov
##      PIS1   PIS2   PIS3   PIS4   PIS5   PIS6
## PIS1  0.000
## PIS2  0.820  0.000
## PIS3  2.548  0.635  0.000
## PIS4 -0.776  0.484 -2.134  0.000
## PIS5 -2.461 -1.375 -1.922  1.567  0.000
## PIS6 -1.752 -0.795 -0.596  0.226  1.939  0.000
##
## $mean
## PIS1 PIS2 PIS3 PIS4 PIS5 PIS6
##    0    0    0    0    0    0
```

```
## Modification indices
modindices(pis.cfa1.fit)
```

```
##     lhs op  rhs     mi    epc sepc.lv sepc.all sepc.nox
## 21 PIS1 ~~ PIS2  0.963  0.048   0.048    0.080    0.080
```

```
## 22 PIS1 ~~ PIS3 13.741  0.167   0.167    0.321    0.321
## 23 PIS1 ~~ PIS4  0.714 -0.043  -0.043   -0.068   -0.068
## 24 PIS1 ~~ PIS5  7.323 -0.147  -0.147   -0.212   -0.212
## 25 PIS1 ~~ PIS6  2.597 -0.077  -0.077   -0.146   -0.146
## 26 PIS2 ~~ PIS3  0.579  0.031   0.031    0.069    0.069
## 27 PIS2 ~~ PIS4  0.424  0.030   0.030    0.054    0.054
## 28 PIS2 ~~ PIS5  1.970 -0.069  -0.069   -0.113   -0.113
## 29 PIS2 ~~ PIS6  0.931 -0.043  -0.043   -0.092   -0.092
## 30 PIS3 ~~ PIS4  3.863 -0.085  -0.085   -0.175   -0.175
## 31 PIS3 ~~ PIS5  3.060 -0.079  -0.079   -0.151   -0.151
## 32 PIS3 ~~ PIS6  0.367 -0.025  -0.025   -0.064   -0.064
## 33 PIS4 ~~ PIS5  4.948  0.115   0.115    0.178    0.178
## 34 PIS4 ~~ PIS6  0.073  0.012   0.012    0.025    0.025
## 35 PIS5 ~~ PIS6  9.768  0.150   0.150    0.281    0.281
```

```r
## Visualize the path model
semPaths(pis.cfa1.fit,
         rotation = 2,
         layout = "tree2",
         what = "std",
         posCol = "black",
         edge.width = 0.5,
         style = "Lisrel",
         fade = T,
         edge.label.position = 0.55)
```




```r
## Model specification
## One factor modified
pis.cfa1m <- '
              # PIS general factor
              gPIS =~ PIS1+PIS2+PIS3+PIS4+PIS5+PIS6

              # Residual covariance
              PIS1 ~~ PIS3
```

```
'

## Model estimation
pis.cfa1m.fit <- sem(pis.cfa1m, data = pis[,-1],
                     missing = "FIML",
                     estimator = "MLR",
                     se="robust.mlr")

## Summary
summary(pis.cfa1m.fit,
        rsquare = TRUE,
        fit.measures = TRUE,
        standardized = TRUE)
```

```
## lavaan 0.6-6 ended normally after 22 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         19
##
##   Number of observations                           222
##   Number of missing patterns                         1
##
## Model Test User Model:
##                                                Standard      Robust
##   Test Statistic                                 15.824      11.417
##   Degrees of freedom                                  8           8
##   P-value (Chi-square)                            0.045       0.179
##   Scaling correction factor                                   1.386
##         Yuan-Bentler correction (Mplus variant)
##
## Model Test Baseline Model:
##
##   Test statistic                              1231.574     869.431
##   Degrees of freedom                                15          15
##   P-value                                        0.000       0.000
##   Scaling correction factor                                  1.417
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.994       0.996
##   Tucker-Lewis Index (TLI)                       0.988       0.993
##
##   Robust Comparative Fit Index (CFI)                         0.996
##   Robust Tucker-Lewis Index (TLI)                            0.993
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -1802.774   -1802.774
##   Scaling correction factor                                  1.023
##       for the MLR correction
##   Loglikelihood unrestricted model (H1)      -1794.862   -1794.862
##   Scaling correction factor                                  1.131
##       for the MLR correction
```

```
##
##   Akaike (AIC)                                3643.547    3643.547
##   Bayesian (BIC)                              3708.198    3708.198
##   Sample-size adjusted Bayesian (BIC)         3647.985    3647.985
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.066       0.044
##   90 Percent confidence interval - lower         0.010       0.000
##   90 Percent confidence interval - upper         0.114       0.089
##   P-value RMSEA <= 0.05                          0.248       0.535
##
##   Robust RMSEA                                               0.052
##   90 Percent confidence interval - lower                     0.000
##   90 Percent confidence interval - upper                     0.114
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.015       0.015
##
## Parameter Estimates:
##
##   Standard errors                             Sandwich
##   Information bread                           Observed
##   Observed information based on                Hessian
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   gPIS =~
##     PIS1              1.000                               1.214    0.811
##     PIS2              1.021    0.058   17.486    0.000    1.239    0.861
##     PIS3              1.031    0.051   20.259    0.000    1.251    0.882
##     PIS4              1.045    0.059   17.798    0.000    1.269    0.858
##     PIS5              1.024    0.066   15.522    0.000    1.243    0.835
##     PIS6              1.175    0.060   19.500    0.000    1.426    0.919
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .PIS1 ~~
##    .PIS3             0.168    0.054    3.121    0.002    0.168    0.287
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .PIS1             2.396    0.100   23.861    0.000    2.396    1.601
##    .PIS2             2.865    0.097   29.655    0.000    2.865    1.990
##    .PIS3             2.383    0.095   25.036    0.000    2.383    1.680
##    .PIS4             2.734    0.099   27.553    0.000    2.734    1.849
##    .PIS5             2.414    0.100   24.168    0.000    2.414    1.622
##    .PIS6             2.356    0.104   22.614    0.000    2.356    1.518
##     gPIS             0.000                               0.000    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .PIS1             0.766    0.093    8.252    0.000    0.766    0.342
```

```
##    .PIS2              0.537    0.071    7.564    0.000    0.537    0.259
##    .PIS3              0.447    0.057    7.858    0.000    0.447    0.222
##    .PIS4              0.576    0.071    8.151    0.000    0.576    0.264
##    .PIS5              0.670    0.098    6.864    0.000    0.670    0.302
##    .PIS6              0.375    0.057    6.584    0.000    0.375    0.155
##     gPIS              1.473    0.172    8.566    0.000    1.000    1.000
##
## R-Square:
##                    Estimate
##     PIS1              0.658
##     PIS2              0.741
##     PIS3              0.778
##     PIS4              0.736
##     PIS5              0.698
##     PIS6              0.845
```

```
## Parameter estimates
parameterEstimates(pis.cfa1m.fit)
```

```
##     lhs op  rhs   est    se      z pvalue ci.lower ci.upper
## 1  gPIS =~ PIS1 1.000 0.000     NA     NA    1.000    1.000
## 2  gPIS =~ PIS2 1.021 0.058 17.486  0.000    0.906    1.135
## 3  gPIS =~ PIS3 1.031 0.051 20.259  0.000    0.931    1.130
## 4  gPIS =~ PIS4 1.045 0.059 17.798  0.000    0.930    1.160
## 5  gPIS =~ PIS5 1.024 0.066 15.522  0.000    0.895    1.154
## 6  gPIS =~ PIS6 1.175 0.060 19.500  0.000    1.057    1.293
## 7  PIS1 ~~ PIS3 0.168 0.054  3.121  0.002    0.062    0.273
## 8  PIS1 ~~ PIS1 0.766 0.093  8.252  0.000    0.584    0.948
## 9  PIS2 ~~ PIS2 0.537 0.071  7.564  0.000    0.398    0.677
## 10 PIS3 ~~ PIS3 0.447 0.057  7.858  0.000    0.335    0.558
## 11 PIS4 ~~ PIS4 0.576 0.071  8.151  0.000    0.438    0.715
## 12 PIS5 ~~ PIS5 0.670 0.098  6.864  0.000    0.479    0.861
## 13 PIS6 ~~ PIS6 0.375 0.057  6.584  0.000    0.263    0.486
## 14 gPIS ~~ gPIS 1.473 0.172  8.566  0.000    1.136    1.810
## 15 PIS1 ~1      2.396 0.100 23.861  0.000    2.200    2.593
## 16 PIS2 ~1      2.865 0.097 29.655  0.000    2.676    3.054
## 17 PIS3 ~1      2.383 0.095 25.036  0.000    2.196    2.569
## 18 PIS4 ~1      2.734 0.099 27.553  0.000    2.540    2.929
## 19 PIS5 ~1      2.414 0.100 24.168  0.000    2.219    2.610
## 20 PIS6 ~1      2.356 0.104 22.614  0.000    2.152    2.560
## 21 gPIS ~1      0.000 0.000     NA     NA    0.000    0.000
```

```
## Standardized residuals
resid(pis.cfa1m.fit, type="standardized")
```

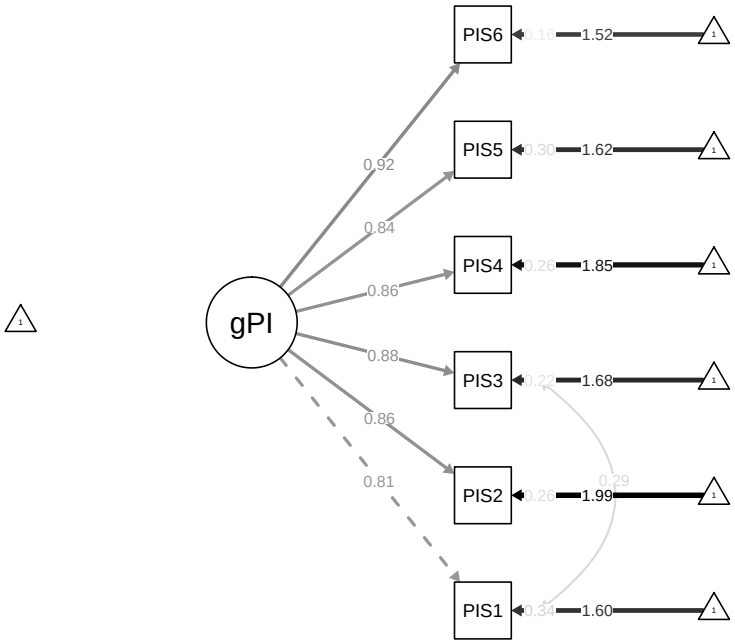
```
## $type
## [1] "standardized"
##
## $cov
##      PIS1   PIS2   PIS3   PIS4   PIS5   PIS6
## PIS1  0.000
## PIS2  1.689  0.000
## PIS3  0.000  1.404  0.000
## PIS4  0.059  0.362 -1.190  0.000
## PIS5 -1.777 -2.000 -1.453  1.173  0.000
## PIS6 -0.265 -1.328  0.367 -0.824  1.477  0.000
```

```
##
## $mean
## PIS1 PIS2 PIS3 PIS4 PIS5 PIS6
##    0    0    0    0    0    0
```

```
## Modification indices
modindices(pis.cfa1m.fit)
```

```
##     lhs op  rhs    mi    epc sepc.lv sepc.all sepc.nox
## 22 PIS1 ~~ PIS2 2.826  0.081   0.081    0.126    0.126
## 23 PIS1 ~~ PIS4 0.142  0.019   0.019    0.028    0.028
## 24 PIS1 ~~ PIS5 2.885 -0.089  -0.089   -0.124   -0.124
## 25 PIS1 ~~ PIS6 0.166 -0.019  -0.019   -0.036   -0.036
## 26 PIS2 ~~ PIS3 1.505  0.049   0.049    0.100    0.100
## 27 PIS2 ~~ PIS4 0.234  0.023   0.023    0.042    0.042
## 28 PIS2 ~~ PIS5 3.517 -0.094  -0.094   -0.157   -0.157
## 29 PIS2 ~~ PIS6 2.395 -0.073  -0.073   -0.162   -0.162
## 30 PIS3 ~~ PIS4 1.421 -0.049  -0.049   -0.097   -0.097
## 31 PIS3 ~~ PIS5 0.480 -0.030  -0.030   -0.055   -0.055
## 32 PIS3 ~~ PIS6 0.274  0.021   0.021    0.051    0.051
## 33 PIS4 ~~ PIS5 2.696  0.085   0.085    0.137    0.137
## 34 PIS4 ~~ PIS6 0.720 -0.041  -0.041   -0.088   -0.088
## 35 PIS5 ~~ PIS6 5.194  0.113   0.113    0.226    0.226
```

```
## Visualize the path model
semPaths(pis.cfa1m.fit,
         rotation = 2,
         layout = "tree2",
         what = "std",
         posCol = "black",
         edge.width = 0.5,
         style = "Lisrel",
         fade = T,
         edge.label.position = 0.55)
```



```
## Model comparison
anova(pis.cfa1.fit, pis.cfa1m.fit)
```

```
## Scaled Chi-Squared Difference Test (method = "satorra.bentler.2001")
##
## lavaan NOTE:
##     The "Chisq" column contains standard test statistics, not the
##     robust test that should be reported per model. A robust difference
##     test is a function of two standard (not robust) statistics.
##
##               Df    AIC    BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## pis.cfa1m.fit  8 3643.5 3708.2 15.823
## pis.cfa1.fit   9 3654.6 3715.9 28.920     9.9148       1    0.00164 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Conclusion Accept the model with robust ML estimation, one general PIS factor (`gPIS`) and one residual covariance. Model `pis.cfa1m` is the final model.

```
## Extract the factor scores
pis.sf <- lavPredict(pis.cfa1m.fit)
head(pis.sf, 5)
```

```
##            gPIS
## [1,] -1.5310263
## [2,] -1.3388278
## [3,]  0.3055426
## [4,]  1.0020314
## [5,] -0.1668300
```

```
## Check by correlating with the sum score
## Define the sum score
pis.sum <- pis$PIS1+
  pis$PIS2+
  pis$PIS3+
  pis$PIS4+
  pis$PIS5+
  pis$PIS6

pis.temp <- data.frame(pis.sum, pis.sf)

## Correlation
cor(pis.temp, use = "pairwise.complete.obs")
```

```
##          pis.sum     gPIS
## pis.sum 1.000000 0.996924
## gPIS    0.996924 1.000000
```

```
## Add the new factor score to the dataset
covid19otlc.tpe$gPIS <- lavPredict(pis.cfa1m.fit)[,c("gPIS")]
```

Perceived institutional support during COVID-19

```
############################################################
## Select the data
pisco.var <- c("UNPERSID", "PISCO1", "PISCO2")
# Subset the data
pisco <- covid19otlc.tpe[pisco.var]
head(pisco, 5)
```

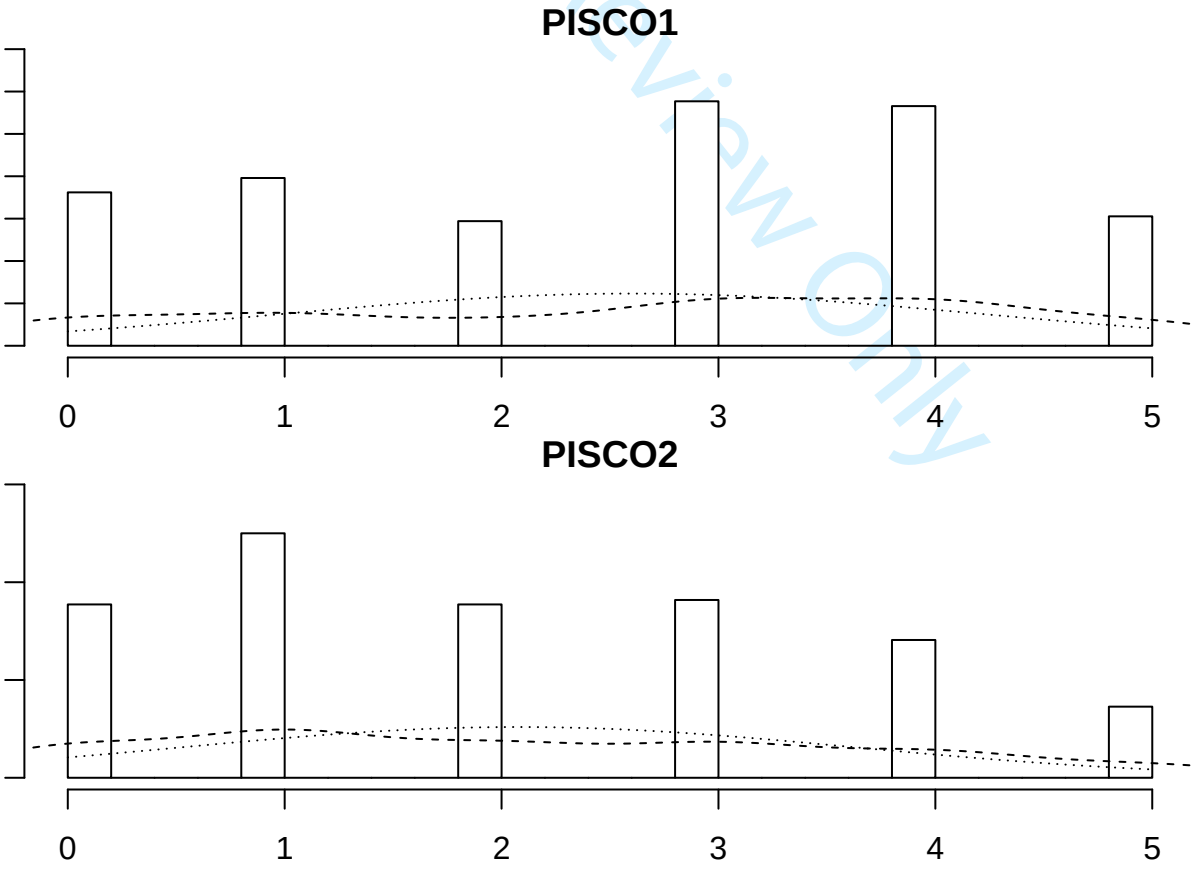
Descriptive scale statistics and correlation matrix

```
##   UNPERSID PISCO1 PISCO2
## 1     4030      0      1
## 2     4312      0      1
## 3     4026      2      2
## 4     4028      3      2
## 5     4032      1      3
```

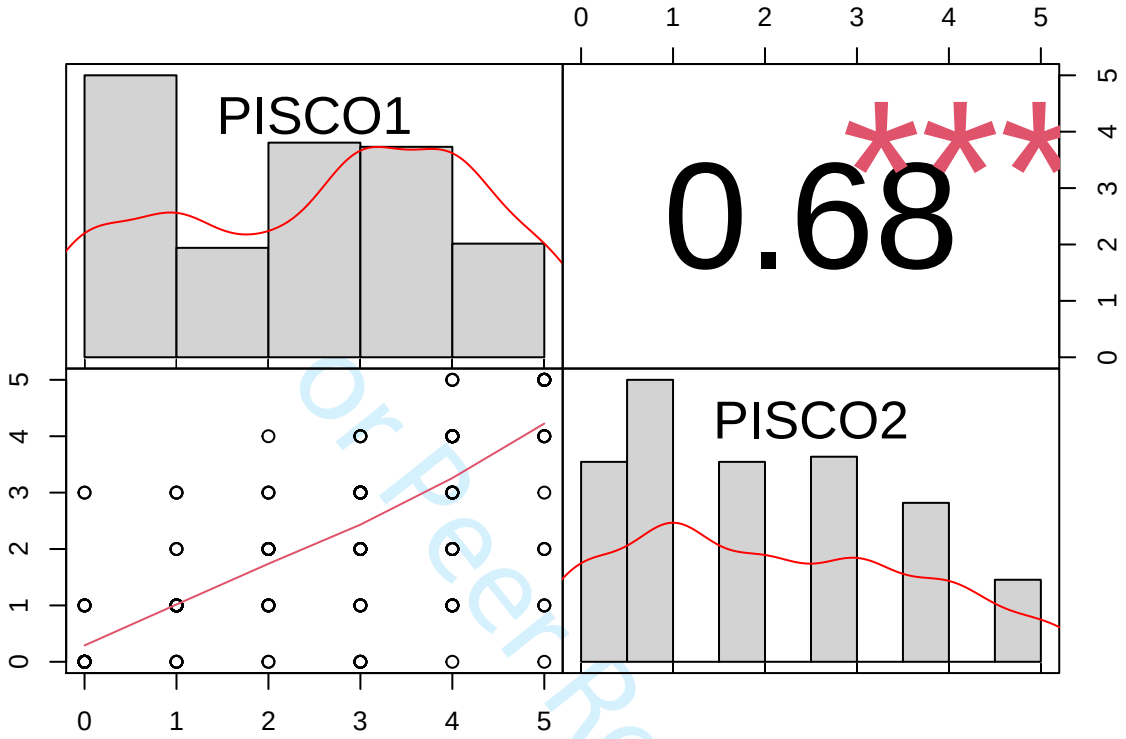
```
############################################################
## Descriptive statistics
describe(pisco[,-1])
```

```
##         vars   n mean   sd median trimmed  mad min max range  skew kurtosis   se
## PISCO1     1 221 2.60 1.62      3    2.63 1.48   0   5     5 -0.21    -1.17 0.11
## PISCO2     2 220 2.08 1.54      2    2.01 1.48   0   5     5  0.29    -1.03 0.10
```

```
## Distributions
multi.hist(pisco[,-1], density = TRUE)
```



```
## Correlation chart
chart.Correlation(pisco[,-1], method = c("pearson"))
```




```
############################################################
## Correlation matrix
## APA format
apa.cor.table(pisco[,-1], filename="Table_PISCO.doc", table.number=3)
```

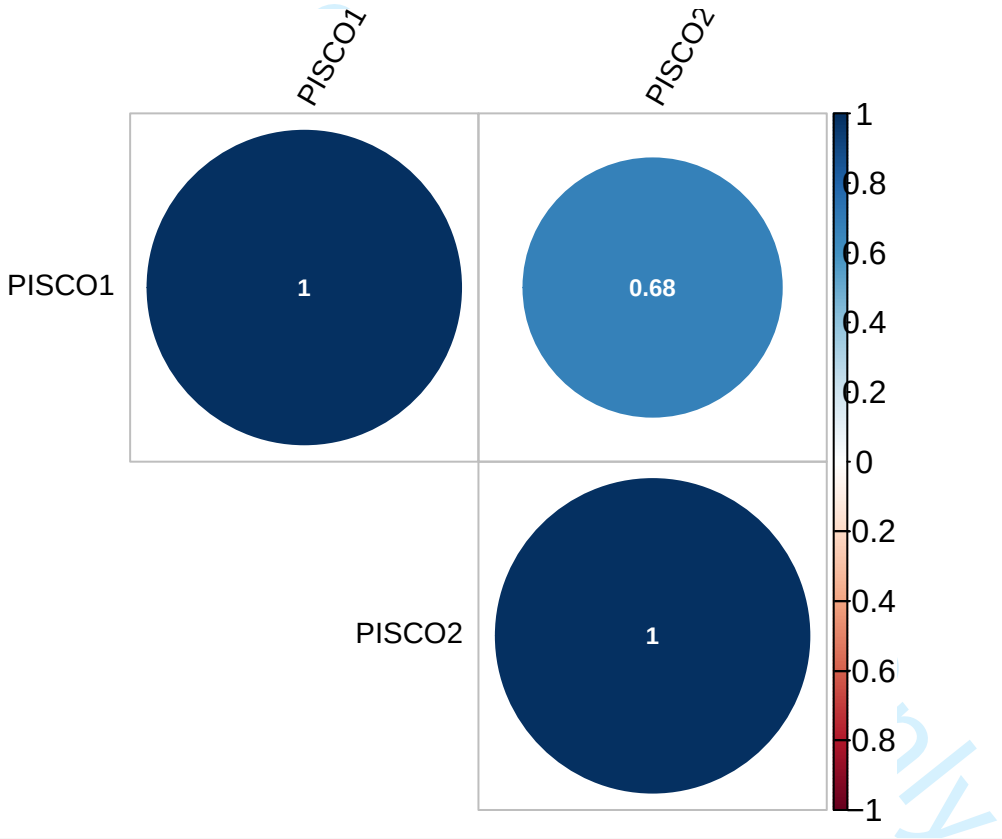
```
##
##
## Table 3
##
## Means, standard deviations, and correlations with confidence intervals
##
##
##   Variable  M    SD   1
##   1. PISCO1 2.60 1.62
##
##   2. PISCO2 2.08 1.54 .68**
##                       [.60, .74]
##
##
## Note. M and SD are used to represent mean and standard deviation, respectively.
## Values in square brackets indicate the 95% confidence interval.
## The confidence interval is a plausible range of population correlations
## that could have caused the sample correlation (Cumming, 2014).
## * indicates p < .05. ** indicates p < .01.
##
```

```
## Extract the Pearson correlation matrix
pisco.cor <- cor(pisco[,-1], method = "pearson",
```

```
                use = "pairwise.complete.obs")
pisco.cor
```

```
##           PISCO1    PISCO2
## PISCO1 1.0000000 0.6785038
## PISCO2 0.6785038 1.0000000
```

```
## Correlogram
corrplot(pisco.cor, type = "upper", order = "hclust",
         tl.col = "black", tl.srt = 60,
         addCoef.col = "white",
         number.cex = 0.75,
         cl.cex = 1,
         tl.cex = 0.9)
```




```
## Extract the polychoric correlation matrix
pisco.pcor <- polychoric(pisco[,-1])
```

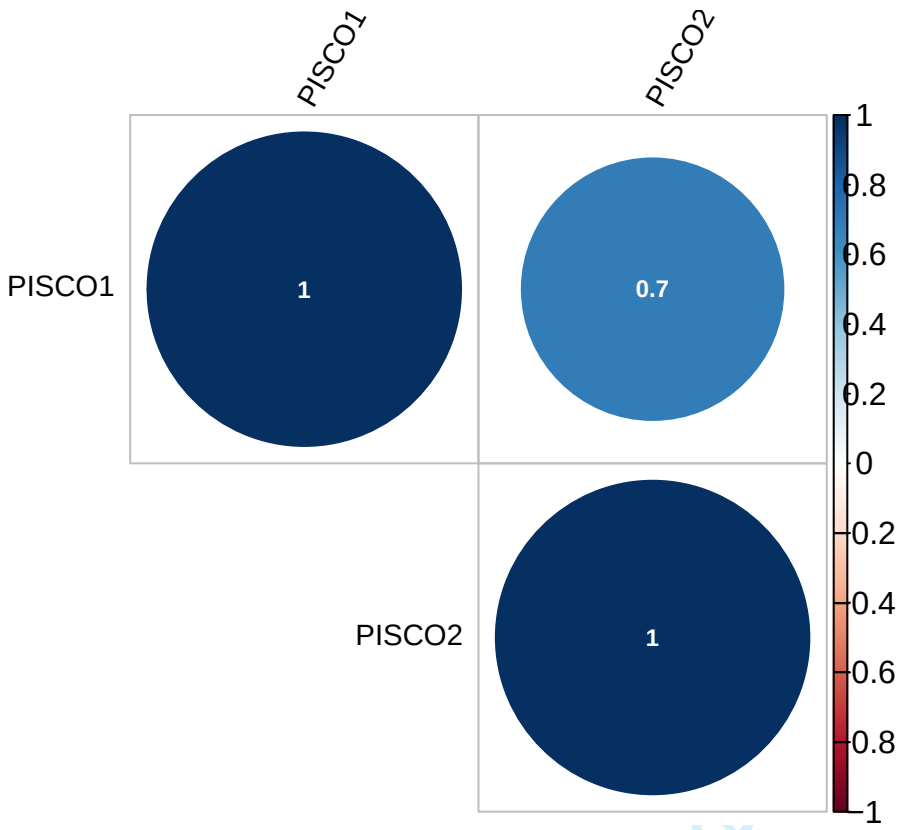
```
## Warning in matpLower(x, nvar, gminx, gmaxx, gminy, gmaxy): 1 cells were adjusted
## for 0 values using the correction for continuity. Examine your data carefully.
```

```
pisco.pcor$rho
```

```
##           PISCO1    PISCO2
## PISCO1 1.0000000 0.6958335
## PISCO2 0.6958335 1.0000000
```

```
## Correlogram
corrplot(pisco.pcor$rho, type = "upper", order = "hclust",
         tl.col = "black", tl.srt = 60,
```

```
         addCoef.col = "white",
         number.cex = 0.75,
         cl.cex = 1,
         tl.cex = 0.9)
```




```
## Absolute difference between the two matrices
pisco.pcor$rho-pisco.cor
```

```
##             PISCO1     PISCO2
## PISCO1 0.00000000 0.01732969
## PISCO2 0.01732969 0.00000000
```

```
max(pisco.pcor$rho-pisco.cor)
```

```
## [1] 0.01732969
```

```
############################################################
```

Descriptive scale statistics and correlation matrix for all perceived institutional support items

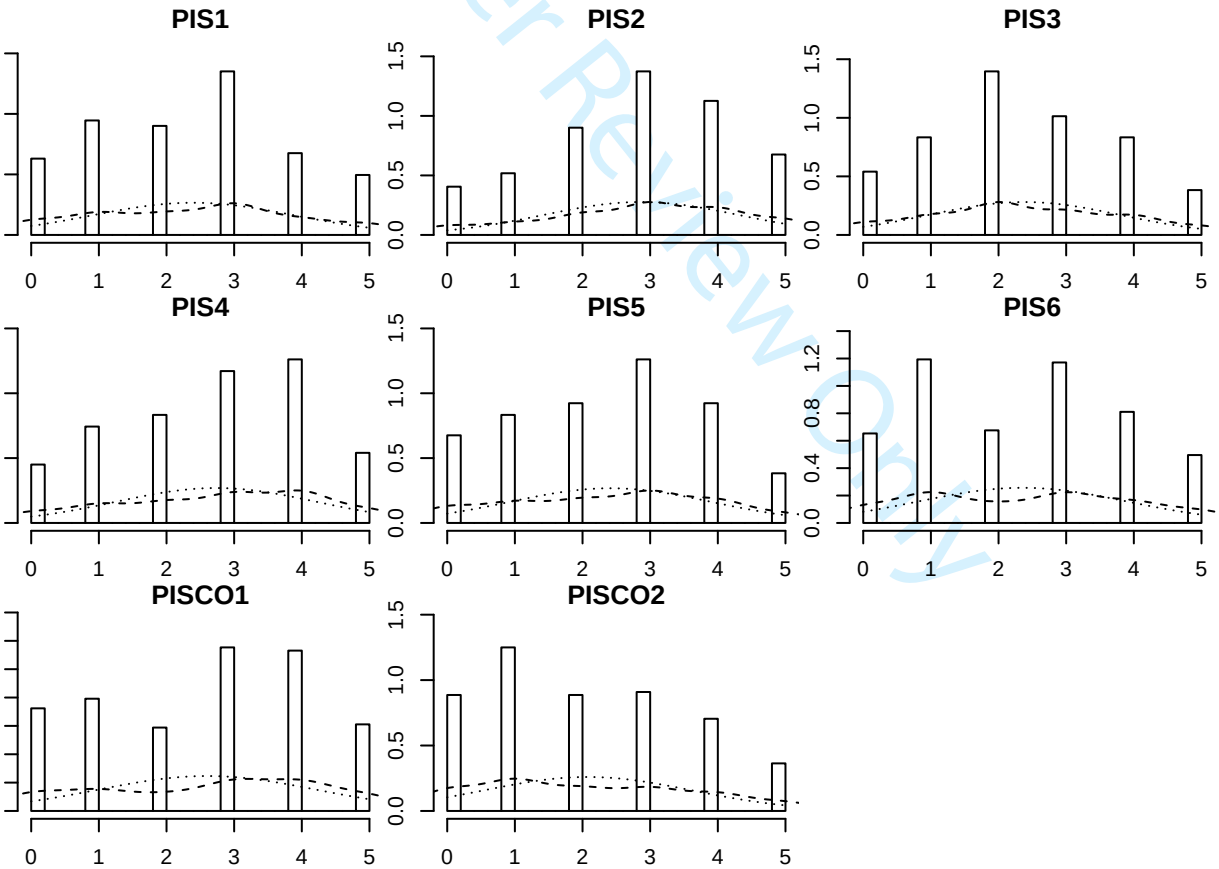
```
############################################################
## Select the data
pisall.var <- c("UNPERSID", "PIS1", "PIS2", "PIS3",
                "PIS4", "PIS5", "PIS6", "PISCO1", "PISCO2")
# Subset the data
pisall <- covid19otlc.tpe[pisall.var]
head(pisall, 5)
```

```
##   UNPERSID PIS1 PIS2 PIS3 PIS4 PIS5 PIS6 PISCO1 PISCO2
## 1     4030    2    0    1    2    1    0      0      1
## 2     4312    2    2    2    1    0    0      0      1
## 3     4026    3    3    3    3    2    3      2      2
## 4     4028    3    4    4    4    2    4      3      2
## 5     4032    2    3    2    3    2    2      1      3
```

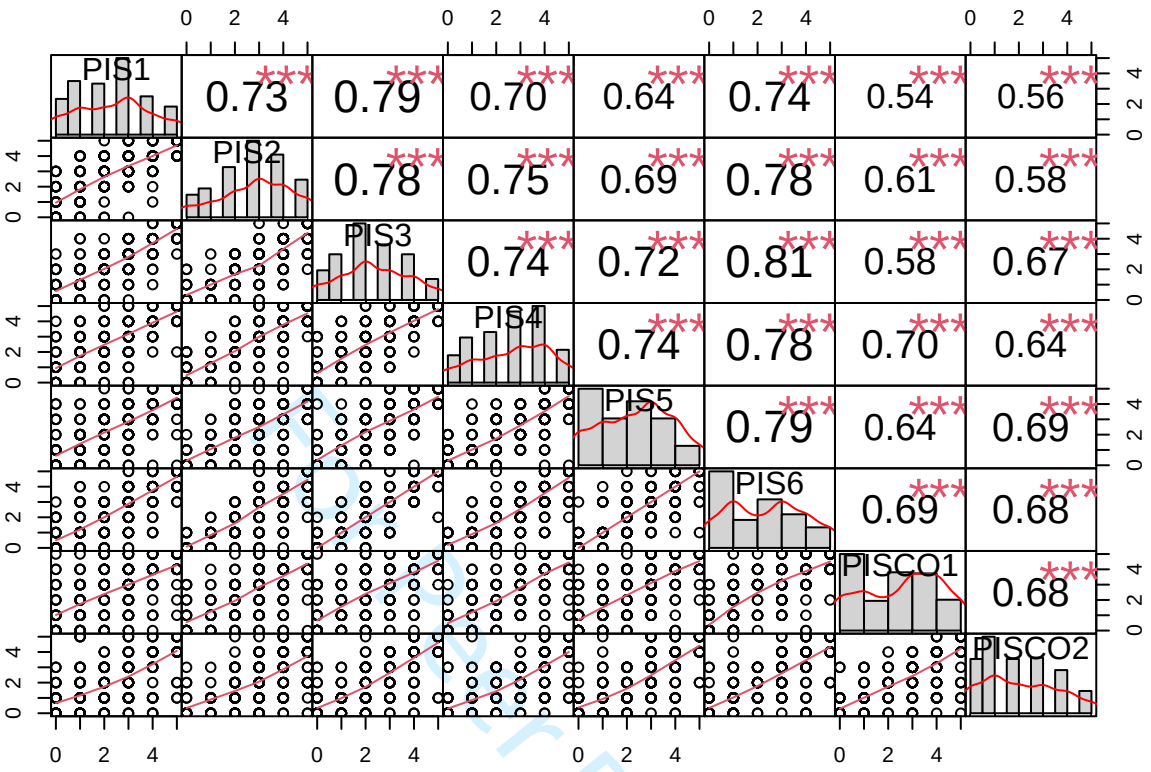
```
############################################################
## Descriptive statistics
describe(pisall[,-1])
```

```
##        vars   n mean   sd median trimmed  mad min max range  skew kurtosis   se
## PIS1      1 222 2.40 1.50      3    2.37 1.48   0   5     5  0.03    -0.95 0.10
## PIS2      2 222 2.86 1.44      3    2.93 1.48   0   5     5 -0.35    -0.69 0.10
## PIS3      3 222 2.38 1.42      2    2.38 1.48   0   5     5  0.07    -0.83 0.10
## PIS4      4 222 2.73 1.48      3    2.78 1.48   0   5     5 -0.28    -0.94 0.10
## PIS5      5 222 2.41 1.49      3    2.42 1.48   0   5     5 -0.08    -1.00 0.10
## PIS6      6 222 2.36 1.56      2    2.32 1.48   0   5     5  0.08    -1.14 0.10
## PISCO1    7 221 2.60 1.62      3    2.63 1.48   0   5     5 -0.21    -1.17 0.11
## PISCO2    8 220 2.08 1.54      2    2.01 1.48   0   5     5  0.29    -1.03 0.10
```

```
## Distributions
multi.hist(pisall[,-1], density = TRUE)
```




```
## Correlation chart
chart.Correlation(pisall[,-1], method = c("pearson"))
```




```
############################################################
## Correlation matrix
## APA format
apa.cor.table(pisall[,-1], filename="Table_PISALL.doc", table.number=8)
```

```
##
##
## Table 8
##
## Means, standard deviations, and correlations with confidence intervals
##
##
##   Variable  M    SD   1          2          3          4          5
##   1. PIS1   2.40 1.50
##
##   2. PIS2   2.86 1.44 .73**
##                       [.67, .79]
##
##   3. PIS3   2.38 1.42 .79**      .78**
##                       [.74, .84] [.73, .83]
##
##   4. PIS4   2.73 1.48 .70**      .75**      .74**
##                       [.62, .76] [.68, .80] [.68, .80]
##
##   5. PIS5   2.41 1.49 .64**      .69**      .72**      .74**
##                       [.56, .71] [.61, .75] [.65, .78] [.68, .80]
##
##   6. PIS6   2.36 1.56 .74**      .78**      .81**      .78**      .79**
##                       [.68, .80] [.72, .82] [.76, .85] [.72, .83] [.73, .83]
##
```

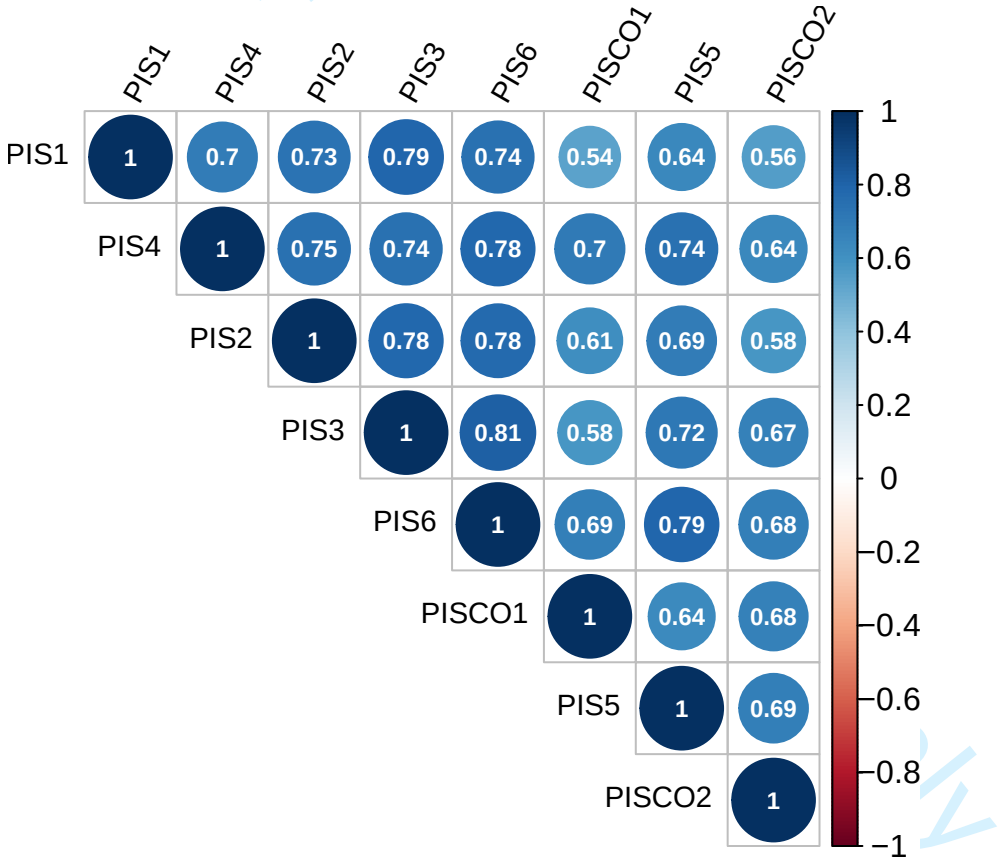
```
##   7. PISCO1 2.60 1.62 .54**      .61**      .58**      .70**      .64**
##                       [.43, .62] [.52, .69] [.49, .66] [.63, .76] [.55, .71]
##
##   8. PISCO2 2.08 1.54 .56**      .58**      .67**      .64**      .69**
##                       [.46, .64] [.49, .66] [.59, .74] [.56, .71] [.61, .75]
##
##   6          7
##
##
##
##
##
##
##
##
##
##
##
##
##
##
##
##
##   .69**
##   [.61, .75]
##
##   .68**      .68**
##   [.61, .75] [.60, .74]
##
##
## Note. M and SD are used to represent mean and standard deviation, respectively.
## Values in square brackets indicate the 95% confidence interval.
## The confidence interval is a plausible range of population correlations
## that could have caused the sample correlation (Cumming, 2014).
## * indicates p < .05. ** indicates p < .01.
##
```

```
## Extract the Pearson correlation matrix
pisall.cor <- cor(pisall[,-1], method = "pearson",
                  use = "pairwise.complete.obs")
pisall.cor
```

```
##             PIS1      PIS2      PIS3      PIS4      PIS5      PIS6    PISCO1
## PIS1   1.0000000 0.7338217 0.7945276 0.6970668 0.6401190 0.7421310 0.5359045
## PIS2   0.7338217 1.0000000 0.7822714 0.7450898 0.6905033 0.7775667 0.6135278
## PIS3   0.7945276 0.7822714 1.0000000 0.7424350 0.7186606 0.8139405 0.5829839
## PIS4   0.6970668 0.7450898 0.7424350 1.0000000 0.7418357 0.7811474 0.7002310
## PIS5   0.6401190 0.6905033 0.7186606 0.7418357 1.0000000 0.7900909 0.6376571
## PIS6   0.7421310 0.7775667 0.8139405 0.7811474 0.7900909 1.0000000 0.6867418
## PISCO1 0.5359045 0.6135278 0.5829839 0.7002310 0.6376571 0.6867418 1.0000000
## PISCO2 0.5570011 0.5834885 0.6721783 0.6407962 0.6896327 0.6841406 0.6785038
##           PISCO2
## PIS1   0.5570011
## PIS2   0.5834885
```

```
## PIS3   0.6721783
## PIS4   0.6407962
## PIS5   0.6896327
## PIS6   0.6841406
## PISCO1 0.6785038
## PISCO2 1.0000000
```

```
## Correlogram
corrplot(pisall.cor, type = "upper", order = "hclust",
         tl.col = "black", tl.srt = 60,
         addCoef.col = "white",
         number.cex = 0.75,
         cl.cex = 1,
         tl.cex = 0.9)
```




```
## Extract the polychoric correlation matrix
pisall.pcor <- polychoric(pisall[,-1])
```

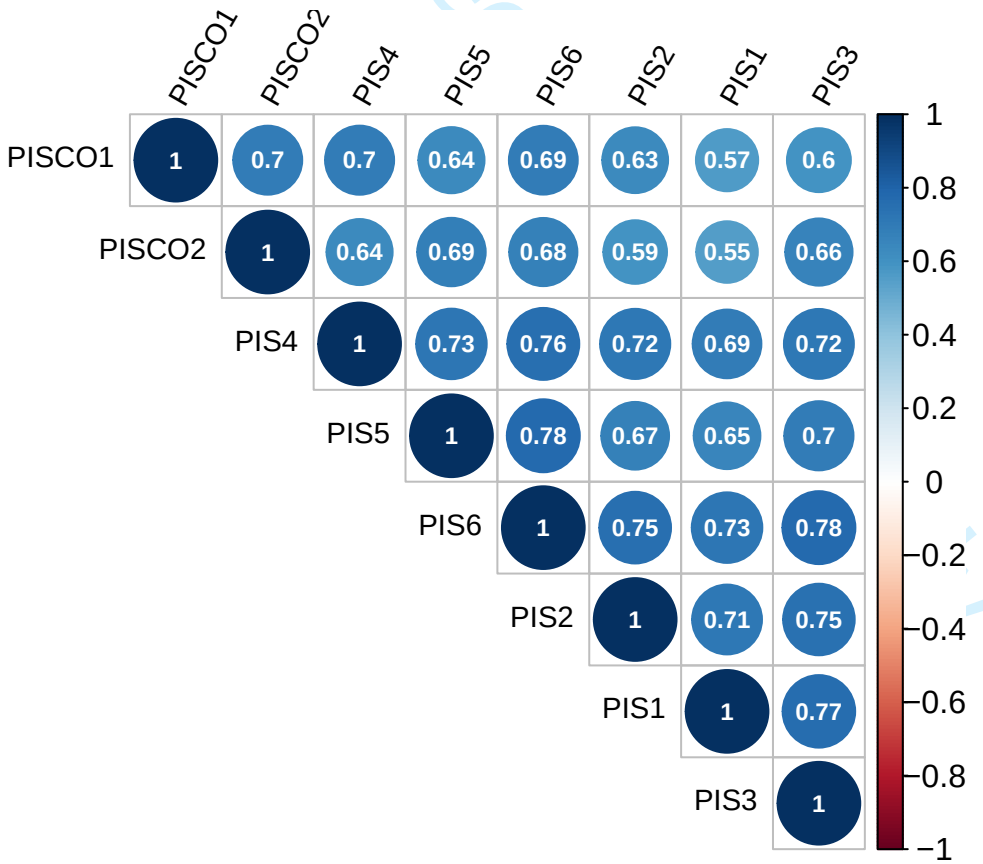
```
## Warning in matpLower(x, nvar, gminx, gmaxx, gminy, gmaxy): 28 cells were
## adjusted for 0 values using the correction for continuity. Examine your data
## carefully.
```

```
pisall.pcor$rho
```

```
##             PIS1      PIS2      PIS3      PIS4      PIS5      PIS6    PISCO1
## PIS1   1.0000000 0.7134438 0.7693800 0.6902077 0.6506381 0.7279092 0.5661267
## PIS2   0.7134438 1.0000000 0.7488392 0.7197437 0.6703412 0.7517822 0.6331714
## PIS3   0.7693800 0.7488392 1.0000000 0.7153792 0.6997897 0.7783809 0.5973230
## PIS4   0.6902077 0.7197437 0.7153792 1.0000000 0.7268357 0.7571224 0.6977315
```

```
## PIS5   0.6506381 0.6703412 0.6997897 0.7268357 1.0000000 0.7785224 0.6394764
## PIS6   0.7279092 0.7517822 0.7783809 0.7571224 0.7785224 1.0000000 0.6928772
## PISCO1 0.5661267 0.6331714 0.5973230 0.6977315 0.6394764 0.6928772 1.0000000
## PISCO2 0.5541362 0.5913969 0.6610563 0.6380182 0.6853330 0.6792687 0.6958335
##           PISCO2
## PIS1   0.5541362
## PIS2   0.5913969
## PIS3   0.6610563
## PIS4   0.6380182
## PIS5   0.6853330
## PIS6   0.6792687
## PISCO1 0.6958335
## PISCO2 1.0000000
```

```
## Correlogram
corrplot(pisall.pcor$rho, type = "upper", order = "hclust",
         tl.col = "black", tl.srt = 60,
         addCoef.col = "white",
         number.cex = 0.75,
         cl.cex = 1,
         tl.cex = 0.9)
```




```
## Absolute difference between the two matrices
pisall.pcor$rho-pisall.cor
```

```
##                PIS1         PIS2        PIS3         PIS4         PIS5
## PIS1    0.000000000 -0.020377933 -0.02514756 -0.006859127  0.010519038
## PIS2   -0.020377933  0.000000000 -0.03343218 -0.025346068 -0.020162154
```

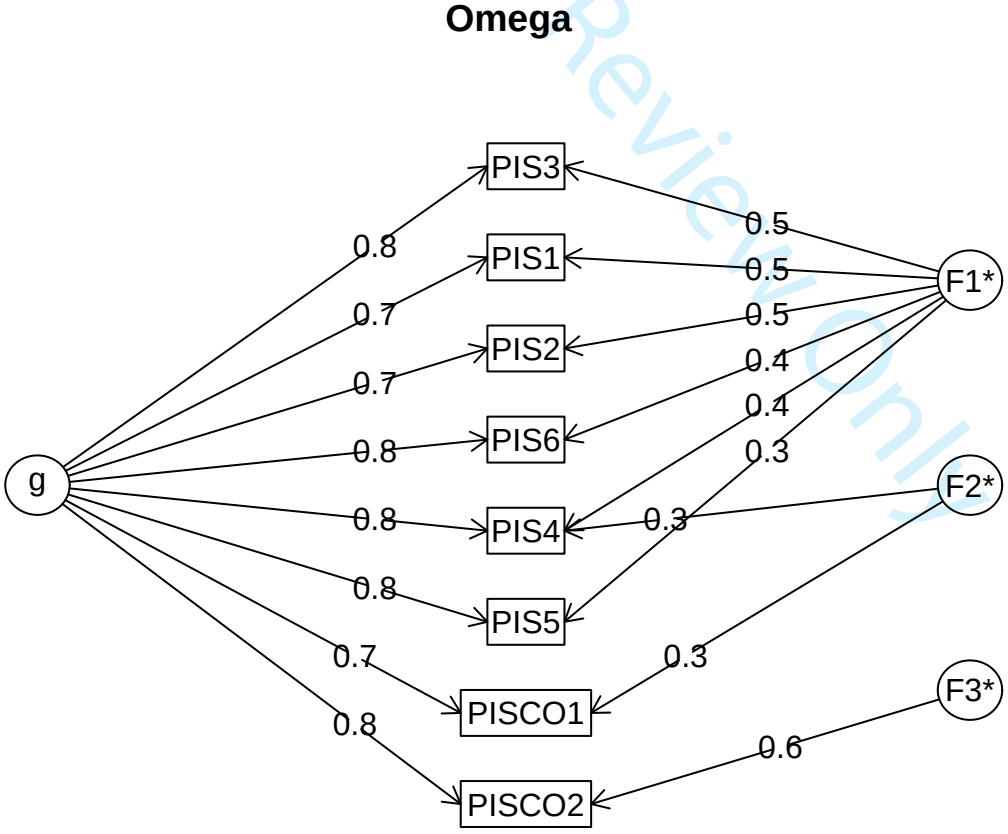
```
## PIS3   -0.025147565 -0.033432181  0.00000000 -0.027055855 -0.018870894
## PIS4   -0.006859127 -0.025346068 -0.02705586  0.000000000 -0.015000024
## PIS5    0.010519038 -0.020162154 -0.01887089 -0.015000024  0.000000000
## PIS6   -0.014221702 -0.025784553 -0.03555957 -0.024024907 -0.011568486
## PISCO1  0.030222242  0.019643574  0.01433910 -0.002499458  0.001819289
## PISCO2 -0.002864984  0.007908374 -0.01112203 -0.002778008 -0.004299718
##                PIS6       PISCO1       PISCO2
## PIS1   -0.014221702  0.030222242 -0.002864984
## PIS2   -0.025784553  0.019643574  0.007908374
## PIS3   -0.035559567  0.014339097 -0.011122027
## PIS4   -0.024024907 -0.002499458 -0.002778008
## PIS5   -0.011568486  0.001819289 -0.004299718
## PIS6    0.000000000  0.006135397 -0.004871821
## PISCO1  0.006135397  0.000000000  0.017329687
## PISCO2 -0.004871821  0.017329687  0.000000000
```

```
max(pisall.pcor$rho-pisall.cor)
```

```
## [1] 0.03022224
```

```
############################################################
## Reliability coefficients (overall scale)
omega(pisall[,-1])
```

```
## Loading required namespace: GPArotation
```




```
## Omega
## Call: omegah(m = m, nfactors = nfactors, fm = fm, key = key, flip = flip,
##     digits = digits, title = title, sl = sl, labels = labels,
```

```
##     plot = plot, n.obs = n.obs, rotate = rotate, Phi = Phi, option = option,
##     covar = covar)
## Alpha:                 0.95
## G.6:                   0.95
## Omega Hierarchical:    0.78
## Omega H asymptotic:    0.81
## Omega Total            0.96
##
## Schmid Leiman Factor loadings greater than  0.2
##           g   F1*   F2*   F3*   h2   u2   p2
## PIS1   0.70  0.49             0.73 0.27 0.66
## PIS2   0.73  0.46             0.75 0.25 0.71
## PIS3   0.78  0.49             0.88 0.12 0.70
## PIS4   0.77  0.36  0.26       0.79 0.21 0.74
## PIS5   0.76  0.30             0.70 0.30 0.81
## PIS6   0.81  0.41             0.83 0.17 0.78
## PISCO1 0.70        0.33       0.66 0.34 0.74
## PISCO2 0.82              0.57 1.00 0.00 0.68
##
## With eigenvalues of:
##    g  F1*  F2*  F3*
## 4.61 1.10 0.26 0.38
##
## general/max  4.18   max/min =   4.24
## mean percent general =  0.73    with sd =  0.05 and cv of  0.07
## Explained Common Variance of the general factor =  0.73
##
## The degrees of freedom are 7  and the fit is  0.05
## The number of observations was  222  with Chi Square =  10.33  with prob <  0.17
## The root mean square of the residuals is  0.01
## The df corrected root mean square of the residuals is  0.02
## RMSEA index =  0.046  and the 10 % confidence intervals are  0 0.102
## BIC =  -27.49
##
## Compare this with the adequacy of just a general factor and no group factors
## The degrees of freedom for just the general factor are 20  and the fit is  1.09
## The number of observations was  222  with Chi Square =  236.97  with prob <  4.8e-39
## The root mean square of the residuals is  0.14
## The df corrected root mean square of the residuals is  0.17
##
## RMSEA index =  0.221  and the 10 % confidence intervals are  0.197 0.247
## BIC =  128.91
##
## Measures of factor score adequacy
##                                                 g   F1*  F2*  F3*
## Correlation of scores with factors            0.91  0.70 0.71 0.78
## Multiple R square of scores with factors      0.82  0.50 0.51 0.61
## Minimum correlation of factor score estimates 0.64 -0.01 0.02 0.22
##
##  Total, General and Subset omega for each subset
##                                                 g  F1*  F2*  F3*
## Omega total for total scores and subscales    0.96 0.95 0.60 1.00
## Omega general for total scores and subscales  0.78 0.73 0.49 0.68
## Omega group for total scores and subscales    0.14 0.22 0.11 0.32
```

```
#############################################################
```

Perceived online teaching presence

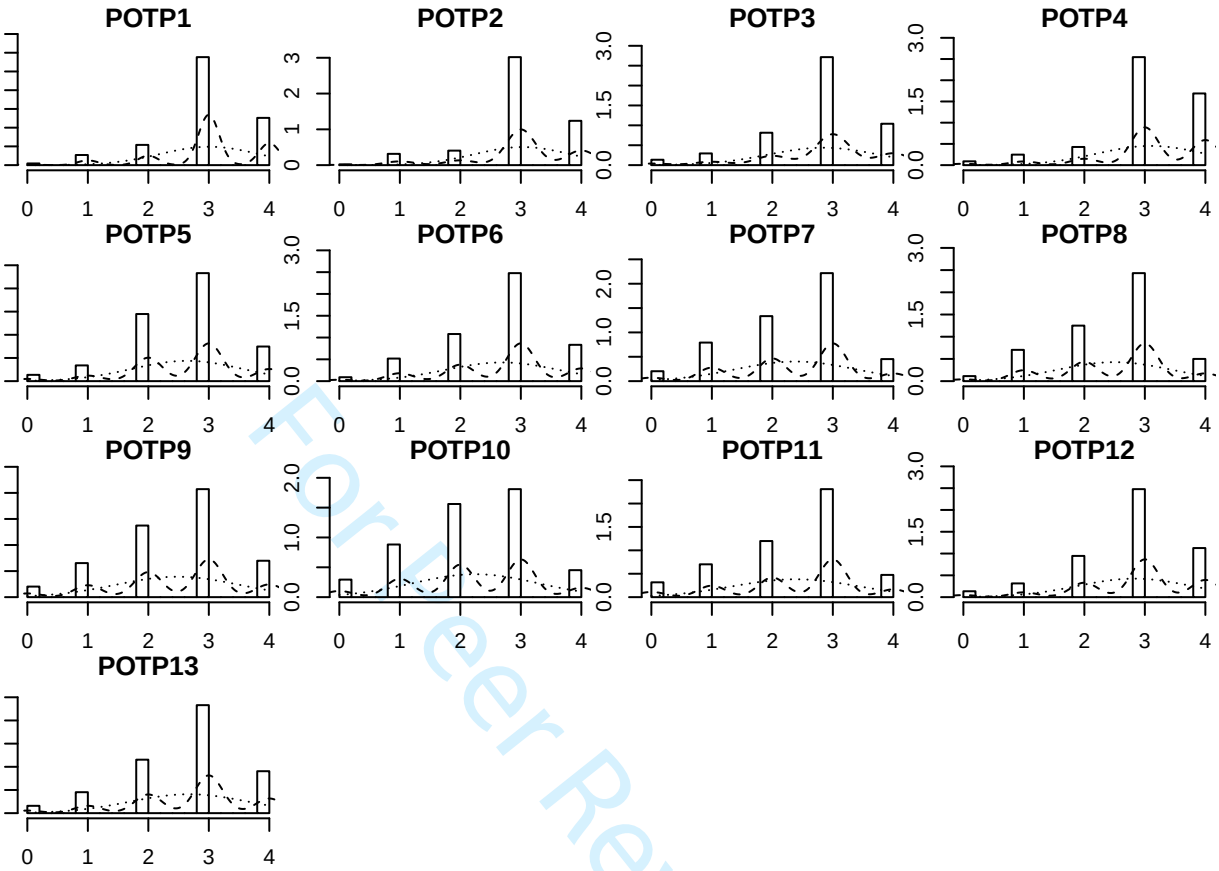
```
#############################################################
## Select the data
pop.var <- c("UNPERSID", "POTP1", "POTP2",
             "POTP3", "POTP4", "POTP5",
             "POTP6", "POTP7", "POTP8",
             "POTP9", "POTP10", "POTP11",
             "POTP12", "POTP13")
# Subset the data
pop <- covid19otlc.tpe[pop.var]
head(pop, 5)
```

Descriptive scale statistics and correlation matrix

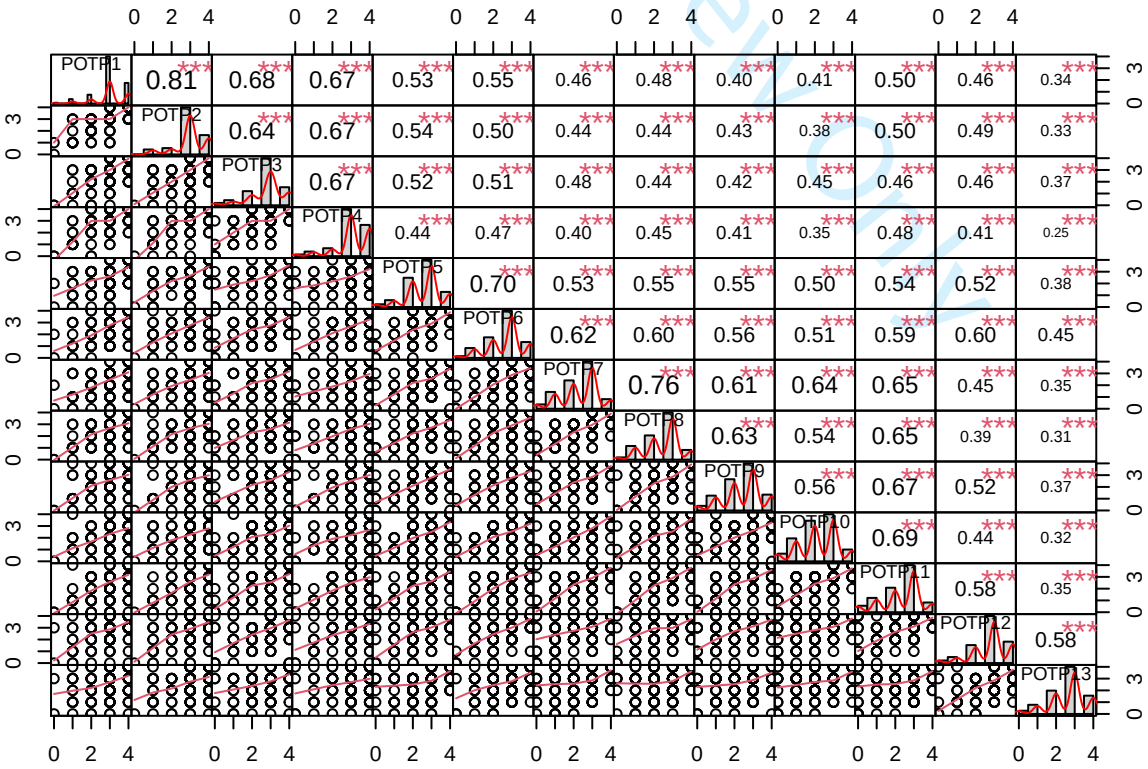
```
##   UNPERSID POTP1 POTP2 POTP3 POTP4 POTP5 POTP6 POTP7 POTP8 POTP9 POTP10 POTP11
## 1     4030     3     2     2     3     2     2     2     2     2      2      2
## 2     4312     3     3     3     3     3     3     3     3     3      3      3
## 3     4026     3     3     3     3     3     3     3     3     3      3      3
## 4     4028     3     3     3     3     2     3     1     1     1      1      1
## 5     4032     4     4     4     4     3     3     2     2     2      2      3
##   POTP12 POTP13
## 1      3      3
## 2      3      1
## 3      3      3
## 4      3      3
## 5      4      4
#############################################################
## Descriptive statistics
describe(pop[,-1])
```

```
##        vars   n mean   sd median trimmed  mad min max range  skew kurtosis   se
## POTP1     1 222 3.01 0.81      3    3.10 0.00   0   4     4 -1.02     1.53 0.05
## POTP2     2 222 3.03 0.79      3    3.12 0.00   0   4     4 -1.04     1.51 0.05
## POTP3     3 221 2.85 0.91      3    2.95 0.00   0   4     4 -1.02     1.23 0.06
## POTP4     4 222 3.10 0.88      3    3.23 0.00   0   4     4 -1.26     1.92 0.06
## POTP5     5 221 2.64 0.91      3    2.71 1.48   0   4     4 -0.64     0.45 0.06
## POTP6     6 222 2.69 0.93      3    2.76 1.48   0   4     4 -0.66     0.10 0.06
## POTP7     7 221 2.38 0.99      3    2.42 1.48   0   4     4 -0.52    -0.33 0.07
## POTP8     8 220 2.50 0.93      3    2.53 1.48   0   4     4 -0.57    -0.17 0.06
## POTP9     9 222 2.48 1.02      3    2.53 1.48   0   4     4 -0.50    -0.26 0.07
## POTP10   10 221 2.25 1.04      2    2.27 1.48   0   4     4 -0.34    -0.51 0.07
## POTP11   11 221 2.38 1.05      3    2.44 1.48   0   4     4 -0.65    -0.25 0.07
## POTP12   12 222 2.83 0.94      3    2.93 1.48   0   4     4 -0.89     0.77 0.06
## POTP13   13 221 2.67 0.98      3    2.76 1.48   0   4     4 -0.71     0.21 0.07
```

```
## Distributions
multi.hist(pop[,-1], density = TRUE)
```




```
## Correlation chart
chart.Correlation(pop[,-1], method = c("pearson"))
```



```
#############################################################
## Correlation matrix
## APA format
apa.cor.table(pop[,-1], filename="Table_POP.doc", table.number=4)
```

```
##
##
## Table 4
##
## Means, standard deviations, and correlations with confidence intervals
##
##
##   Variable   M    SD   1          2          3          4          5
##   1. POTP1   3.01 0.81
##
##   2. POTP2   3.03 0.79 .81**
##                       [.76, .85]
##
##   3. POTP3   2.85 0.91 .68**      .64**
##                       [.60, .75] [.55, .71]
##
##   4. POTP4   3.10 0.88 .67**      .67**      .67**
##                       [.60, .74] [.59, .74] [.59, .74]
##
##   5. POTP5   2.64 0.91 .53**      .54**      .52**      .44**
##                       [.43, .62] [.44, .63] [.42, .61] [.33, .54]
##
##   6. POTP6   2.69 0.93 .55**      .50**      .51**      .47**      .70**
##                       [.46, .64] [.40, .60] [.41, .60] [.36, .56] [.62, .76]
##
##   7. POTP7   2.38 0.99 .46**      .44**      .48**      .40**      .53**
##                       [.35, .56] [.33, .54] [.37, .57] [.28, .51] [.43, .62]
##
##   8. POTP8   2.50 0.93 .48**      .44**      .44**      .45**      .55**
##                       [.37, .58] [.33, .54] [.33, .54] [.34, .55] [.45, .64]
##
##   9. POTP9   2.48 1.02 .40**      .43**      .42**      .41**      .55**
##                       [.28, .50] [.32, .53] [.31, .52] [.29, .51] [.45, .63]
##
##   10. POTP10 2.25 1.04 .41**      .38**      .45**      .35**      .50**
##                       [.29, .51] [.26, .49] [.33, .55] [.22, .46] [.39, .59]
##
##   11. POTP11 2.38 1.05 .50**      .50**      .46**      .48**      .54**
##                       [.39, .59] [.39, .59] [.35, .56] [.37, .58] [.44, .63]
##
##   12. POTP12 2.83 0.94 .46**      .49**      .46**      .41**      .52**
##                       [.35, .56] [.38, .58] [.35, .56] [.29, .51] [.42, .61]
##
##   13. POTP13 2.67 0.98 .34**      .33**      .37**      .25**      .38**
##                       [.22, .45] [.21, .44] [.25, .48] [.12, .37] [.26, .49]
##
##   6          7          8          9          10         11         12
##
##
```

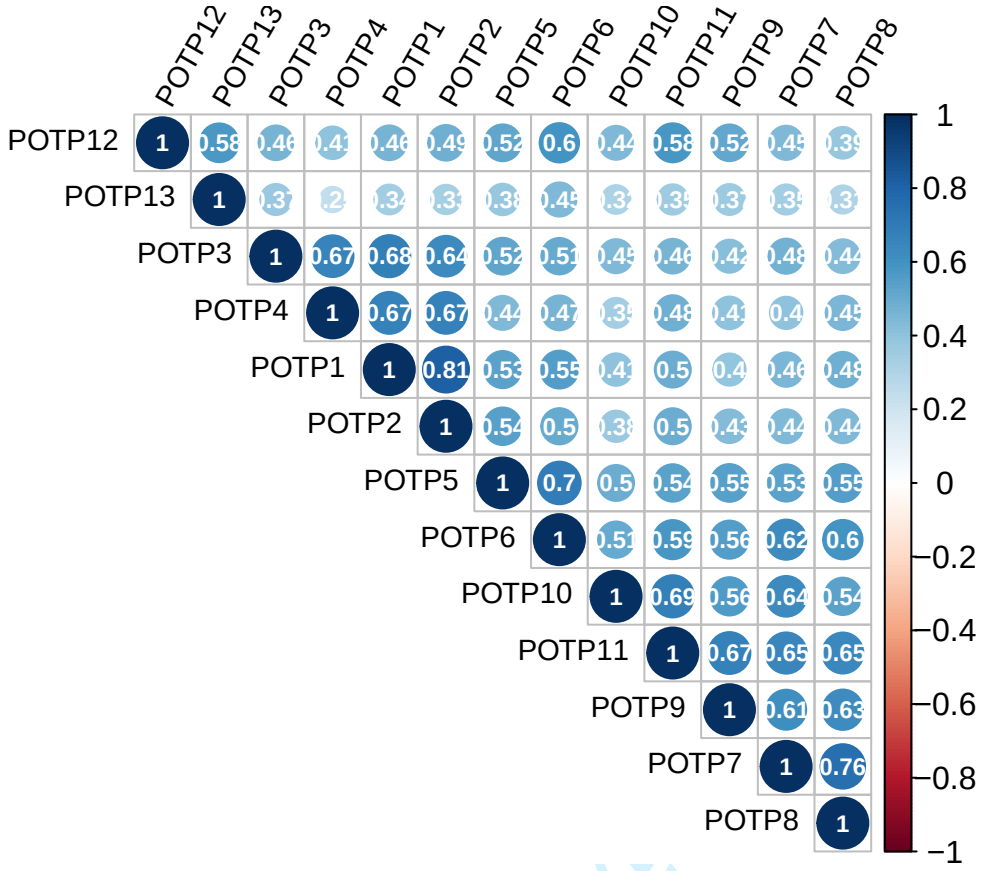
```
##
##
##
##
##
##
##
##
##
##
##
##
##
##
##   .62**
##   [.53, .70]
##
##   .60**      .76**
##   [.51, .68] [.70, .81]
##
##   .56**      .61**      .63**
##   [.46, .64] [.53, .69] [.54, .70]
##
##   .51**      .64**      .54**      .56**
##   [.40, .60] [.55, .71] [.43, .62] [.47, .65]
##
##   .59**      .65**      .65**      .67**      .69**
##   [.50, .67] [.57, .72] [.56, .72] [.60, .74] [.61, .75]
##
##   .60**      .45**      .39**      .52**      .44**      .58**
##   [.50, .67] [.34, .55] [.27, .50] [.41, .61] [.33, .54] [.49, .66]
##
##   .45**      .35**      .31**      .37**      .32**      .35**      .58**
##   [.34, .55] [.23, .46] [.18, .42] [.25, .48] [.19, .43] [.23, .46] [.48, .66]
##
##
## Note. M and SD are used to represent mean and standard deviation, respectively.
## Values in square brackets indicate the 95% confidence interval.
## The confidence interval is a plausible range of population correlations
## that could have caused the sample correlation (Cumming, 2014).
## * indicates p < .05. ** indicates p < .01.
##
```

```
## Extract the Pearson correlation matrix
pop.cor <- cor(pop[,-1], method = "pearson",
               use = "pairwise.complete.obs")
pop.cor
```

```
##            POTP1     POTP2     POTP3     POTP4     POTP5     POTP6     POTP7
## POTP1  1.0000000 0.8103261 0.6814345 0.6743608 0.5308888 0.5538818 0.4571251
## POTP2  0.8103261 1.0000000 0.6358517 0.6719275 0.5427567 0.5038110 0.4441532
## POTP3  0.6814345 0.6358517 1.0000000 0.6687675 0.5201198 0.5099073 0.4752220
## POTP4  0.6743608 0.6719275 0.6687675 1.0000000 0.4440814 0.4676353 0.4016280
## POTP5  0.5308888 0.5427567 0.5201198 0.4440814 1.0000000 0.6978254 0.5331014
```

```
## POTP6  0.5538818 0.5038110 0.5099073 0.4676353 0.6978254 1.0000000 0.6205266
## POTP7  0.4571251 0.4441532 0.4752220 0.4016280 0.5331014 0.6205266 1.0000000
## POTP8  0.4825049 0.4423667 0.4396419 0.4512816 0.5523308 0.5980171 0.7587730
## POTP9  0.3990841 0.4336034 0.4201219 0.4099637 0.5467491 0.5593312 0.6146027
## POTP10 0.4056490 0.3787830 0.4463975 0.3463604 0.4964343 0.5074800 0.6362175
## POTP11 0.4977668 0.4983145 0.4631559 0.4800295 0.5372823 0.5899335 0.6523131
## POTP12 0.4637443 0.4875106 0.4618864 0.4079414 0.5207035 0.5952476 0.4493030
## POTP13 0.3433160 0.3316495 0.3704740 0.2479977 0.3801801 0.4479453 0.3492794
##           POTP8     POTP9    POTP10    POTP11    POTP12    POTP13
## POTP1  0.4825049 0.3990841 0.4056490 0.4977668 0.4637443 0.3433160
## POTP2  0.4423667 0.4336034 0.3787830 0.4983145 0.4875106 0.3316495
## POTP3  0.4396419 0.4201219 0.4463975 0.4631559 0.4618864 0.3704740
## POTP4  0.4512816 0.4099637 0.3463604 0.4800295 0.4079414 0.2479977
## POTP5  0.5523308 0.5467491 0.4964343 0.5372823 0.5207035 0.3801801
## POTP6  0.5980171 0.5593312 0.5074800 0.5899335 0.5952476 0.4479453
## POTP7  0.7587730 0.6146027 0.6362175 0.6523131 0.4493030 0.3492794
## POTP8  1.0000000 0.6267871 0.5364611 0.6462305 0.3881878 0.3053643
## POTP9  0.6267871 1.0000000 0.5644087 0.6742784 0.5161661 0.3680948
## POTP10 0.5364611 0.5644087 1.0000000 0.6855247 0.4432126 0.3177568
## POTP11 0.6462305 0.6742784 0.6855247 1.0000000 0.5842073 0.3536275
## POTP12 0.3881878 0.5161661 0.4432126 0.5842073 1.0000000 0.5774486
## POTP13 0.3053643 0.3680948 0.3177568 0.3536275 0.5774486 1.0000000
```

```r
## Correlogram
corrplot(pop.cor, type = "upper", order = "hclust",
         tl.col = "black", tl.srt = 60,
         addCoef.col = "white",
         number.cex = 0.75,
         cl.cex = 1,
         tl.cex = 0.9)
```




```
## Extract the polychoric correlation matrix
pop.pcor <- polychoric(pop[,-1])
```

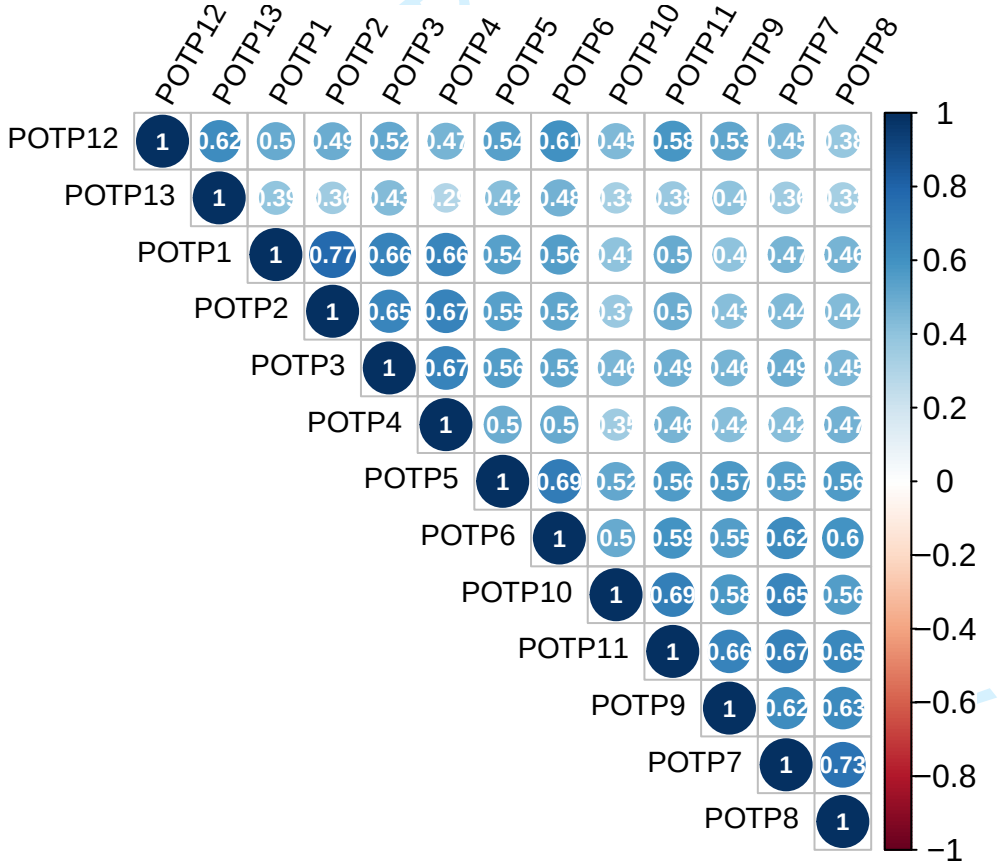
```
## Warning in matpLower(x, nvar, gminx, gmaxx, gminy, gmaxy): 78 cells were
## adjusted for 0 values using the correction for continuity. Examine your data
## carefully.
```

```
pop.pcor$rho
```

```
##             POTP1     POTP2     POTP3     POTP4     POTP5     POTP6     POTP7
## POTP1   1.0000000 0.7726709 0.6648892 0.6583485 0.5427171 0.5585556 0.4676284
## POTP2   0.7726709 1.0000000 0.6528435 0.6658735 0.5462131 0.5226542 0.4433279
## POTP3   0.6648892 0.6528435 1.0000000 0.6699183 0.5597436 0.5280153 0.4918584
## POTP4   0.6583485 0.6658735 0.6699183 1.0000000 0.4959930 0.5025671 0.4245080
## POTP5   0.5427171 0.5462131 0.5597436 0.4959930 1.0000000 0.6910721 0.5488116
## POTP6   0.5585556 0.5226542 0.5280153 0.5025671 0.6910721 1.0000000 0.6213966
## POTP7   0.4676284 0.4433279 0.4918584 0.4245080 0.5488116 0.6213966 1.0000000
## POTP8   0.4640050 0.4363005 0.4505643 0.4734931 0.5614348 0.5968617 0.7346081
## POTP9   0.4022980 0.4257593 0.4626922 0.4237760 0.5707197 0.5522856 0.6206613
## POTP10 0.4096451 0.3718781 0.4569742 0.3504345 0.5159172 0.5040182 0.6512943
## POTP11 0.5021526 0.4991288 0.4892921 0.4649287 0.5616409 0.5935248 0.6718621
## POTP12 0.5019769 0.4938782 0.5188580 0.4668675 0.5432187 0.6055871 0.4509697
## POTP13 0.3928501 0.3575474 0.4307280 0.2917568 0.4217978 0.4754685 0.3593197
##             POTP8     POTP9    POTP10    POTP11    POTP12    POTP13
## POTP1   0.4640050 0.4022980 0.4096451 0.5021526 0.5019769 0.3928501
## POTP2   0.4363005 0.4257593 0.3718781 0.4991288 0.4938782 0.3575474
## POTP3   0.4505643 0.4626922 0.4569742 0.4892921 0.5188580 0.4307280
```

```
## POTP4  0.4734931 0.4237760 0.3504345 0.4649287 0.4668675 0.2917568
## POTP5  0.5614348 0.5707197 0.5159172 0.5616409 0.5432187 0.4217978
## POTP6  0.5968617 0.5522856 0.5040182 0.5935248 0.6055871 0.4754685
## POTP7  0.7346081 0.6206613 0.6512943 0.6718621 0.4509697 0.3593197
## POTP8  1.0000000 0.6328578 0.5584362 0.6467276 0.3804193 0.3304199
## POTP9  0.6328578 1.0000000 0.5787724 0.6609319 0.5261405 0.4029236
## POTP10 0.5584362 0.5787724 1.0000000 0.6898980 0.4490189 0.3325048
## POTP11 0.6467276 0.6609319 0.6898980 1.0000000 0.5824284 0.3756883
## POTP12 0.3804193 0.5261405 0.4490189 0.5824284 1.0000000 0.6222968
## POTP13 0.3304199 0.4029236 0.3325048 0.3756883 0.6222968 1.0000000
```

```
## Correlogram
corrplot(pop.pcor$rho, type = "upper", order = "hclust",
         tl.col = "black", tl.srt = 60,
         addCoef.col = "white",
         number.cex = 0.75,
         cl.cex = 1,
         tl.cex = 0.9)
```




```
## Absolute difference between the two matrices
pop.pcor$rho-pop.cor
```

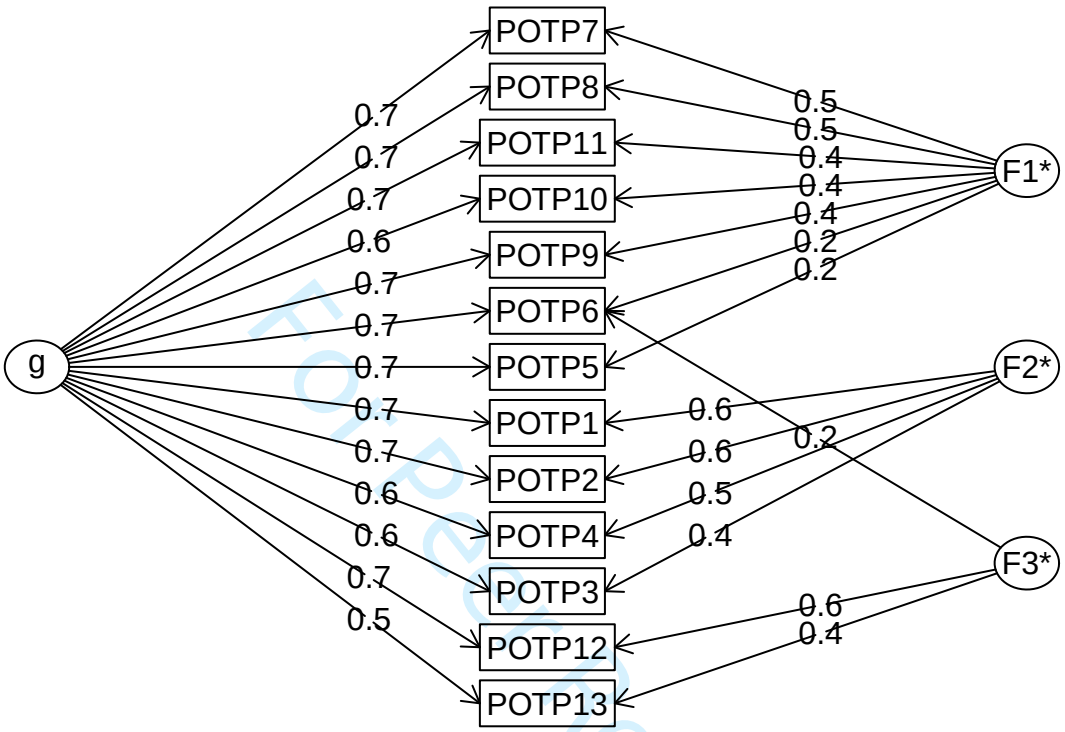
```
##               POTP1         POTP2         POTP3         POTP4         POTP5
## POTP1   0.000000000 -0.0376551784 -0.016545271 -0.016012339  0.011828226
## POTP2  -0.037655178  0.0000000000  0.016991748 -0.006053907  0.003456402
## POTP3  -0.016545271  0.0169917478  0.000000000  0.001150771  0.039623781
## POTP4  -0.016012339 -0.0060539075  0.001150771  0.000000000  0.051911555
## POTP5   0.011828226  0.0034564016  0.039623781  0.051911555  0.000000000
```

```
## POTP6   0.004673802  0.0188432432  0.018107920  0.034931798 -0.006753257
## POTP7   0.010503259 -0.0008252357  0.016636425  0.022879995  0.015710199
## POTP8  -0.018499952 -0.0060661974  0.010922449  0.022211524  0.009103982
## POTP9   0.003213870 -0.0078440769  0.042570226  0.013812293  0.023970612
## POTP10  0.003996088 -0.0069049353  0.010576638  0.004074105  0.019482833
## POTP11  0.004385814  0.0008142772  0.026136198 -0.015100762  0.024358631
## POTP12  0.038232605  0.0063675498  0.056971541  0.058926134  0.022515131
## POTP13  0.049534100  0.0258978713  0.060254013  0.043759093  0.041617667
##                POTP6         POTP7         POTP8        POTP9        POTP10
## POTP1   0.0046738023  0.0105032589 -0.0184999522  0.003213870  0.003996088
## POTP2   0.0188432432 -0.0008252357 -0.0060661974 -0.007844077 -0.006904935
## POTP3   0.0181079199  0.0166364246  0.0109224490  0.042570226  0.010576638
## POTP4   0.0349317976  0.0228799955  0.0222115241  0.013812293  0.004074105
## POTP5  -0.0067532567  0.0157101992  0.0091039815  0.023970612  0.019482833
## POTP6   0.0000000000  0.0008700418 -0.0011553176 -0.007045591 -0.003461842
## POTP7   0.0008700418  0.0000000000 -0.0241648939  0.006058615  0.015076790
## POTP8  -0.0011553176 -0.0241648939  0.0000000000  0.006070708  0.021975083
## POTP9  -0.0070455910  0.0060586154  0.0060707080  0.000000000  0.014363772
## POTP10 -0.0034618416  0.0150767905  0.0219750826  0.014363772  0.000000000
## POTP11  0.0035913157  0.0195489832  0.0004971692 -0.013346445  0.004373306
## POTP12  0.0103394914  0.0016666763 -0.0077685460  0.009974415  0.005806245
## POTP13  0.0275232247  0.0100402740  0.0250555738  0.034828761  0.014748014
##               POTP11       POTP12   POTP13
## POTP1   0.0043858139  0.038232605 0.04953410
## POTP2   0.0008142772  0.006367550 0.02589787
## POTP3   0.0261361977  0.056971541 0.06025401
## POTP4  -0.0151007616  0.058926134 0.04375909
## POTP5   0.0243586308  0.022515131 0.04161767
## POTP6   0.0035913157  0.010339491 0.02752322
## POTP7   0.0195489832  0.001666676 0.01004027
## POTP8   0.0004971692 -0.007768546 0.02505557
## POTP9  -0.0133464451  0.009974415 0.03482876
## POTP10  0.0043733060  0.005806245 0.01474801
## POTP11  0.0000000000 -0.001778916 0.02206081
## POTP12 -0.0017789164  0.000000000 0.04484816
## POTP13  0.0220608090  0.044848157 0.00000000
```

```
max(pop.pcor$rho-pop.cor)
```

```
## [1] 0.06025401
```

```
############################################################
## Reliability coefficients (overall scale)
omega(pop[,-1])
```




```
## Omega
## Call: omegah(m = m, nfactors = nfactors, fm = fm, key = key, flip = flip,
##     digits = digits, title = title, sl = sl, labels = labels,
##     plot = plot, n.obs = n.obs, rotate = rotate, Phi = Phi, option = option,
##     covar = covar)
## Alpha:                 0.93
## G.6:                   0.94
## Omega Hierarchical:    0.78
## Omega H asymptotic:    0.82
## Omega Total            0.95
##
## Schmid Leiman Factor loadings greater than  0.2
##           g   F1*   F2*   F3*   h2   u2   p2
## POTP1  0.68        0.58       0.80 0.20 0.58
## POTP2  0.67        0.55       0.75 0.25 0.59
## POTP3  0.64        0.44       0.61 0.39 0.68
## POTP4  0.60        0.51       0.62 0.38 0.58
## POTP5  0.67  0.22             0.54 0.46 0.82
## POTP6  0.71  0.25       0.22  0.63 0.37 0.81
## POTP7  0.69  0.51             0.73 0.27 0.64
## POTP8  0.66  0.50             0.70 0.30 0.63
## POTP9  0.65  0.39             0.60 0.40 0.72
## POTP10 0.61  0.40             0.54 0.46 0.70
## POTP11 0.71  0.40             0.68 0.32 0.75
## POTP12 0.67              0.58 0.78 0.22 0.57
## POTP13 0.48              0.42 0.41 0.59 0.56
##
```

```
## With eigenvalues of:
##    g  F1*  F2*  F3*
## 5.55 1.09 1.13 0.63
##
## general/max  4.92   max/min =   1.78
## mean percent general =  0.66    with sd =  0.09 and cv of  0.14
## Explained Common Variance of the general factor =  0.66
##
## The degrees of freedom are 42  and the fit is  0.52
## The number of observations was  222  with Chi Square =  111.47  with prob <  3.3e-08
## The root mean square of the residuals is  0.03
## The df corrected root mean square of the residuals is  0.04
## RMSEA index =  0.086  and the 10 % confidence intervals are  0.067 0.106
## BIC =  -115.44
##
## Compare this with the adequacy of just a general factor and no group factors
## The degrees of freedom for just the general factor are 65  and the fit is  2.31
## The number of observations was  222  with Chi Square =  498.02  with prob <  5.4e-68
## The root mean square of the residuals is  0.12
## The df corrected root mean square of the residuals is  0.13
##
## RMSEA index =  0.173  and the 10 % confidence intervals are  0.16 0.188
## BIC =  146.84
##
## Measures of factor score adequacy
##                                                 g   F1*  F2*  F3*
## Correlation of scores with factors            0.89  0.70 0.77 0.74
## Multiple R square of scores with factors      0.79  0.49 0.59 0.55
## Minimum correlation of factor score estimates 0.57 -0.02 0.18 0.10
##
##  Total, General and Subset omega for each subset
##                                                 g  F1*  F2*  F3*
## Omega total for total scores and subscales    0.95 0.91 0.90 0.74
## Omega general for total scores and subscales  0.78 0.69 0.55 0.42
## Omega group for total scores and subscales    0.14 0.22 0.35 0.32
############################################################
```

```
## Model specification
## One factor
pop.cfa1 <- '
              # POP general factor
              gPOP =~ POTP1+POTP2+POTP3+
                      POTP4+POTP5+POTP6+
                      POTP7+POTP8+POTP9+
                      POTP10+POTP11+POTP12+
                      POTP13
'

## Model estimation
pop.cfa1.fit <- sem(pop.cfa1, data = pop[,-1],
                    missing = "FIML",
                    estimator = "MLR",
```

```
                      se="robust.mlr")

## Summary
summary(pop.cfa1.fit,
        rsquare = TRUE,
        fit.measures = TRUE,
        standardized = TRUE)
```

Measurement model

```
## lavaan 0.6-6 ended normally after 50 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         39
##
##   Number of observations                           222
##   Number of missing patterns                         8
##
## Model Test User Model:
##                                                Standard      Robust
##   Test Statistic                                470.622     323.305
##   Degrees of freedom                                 65          65
##   P-value (Chi-square)                            0.000       0.000
##   Scaling correction factor                                   1.456
##         Yuan-Bentler correction (Mplus variant)
##
## Model Test Baseline Model:
##
##   Test statistic                               1961.206    1334.000
##   Degrees of freedom                                 78          78
##   P-value                                         0.000       0.000
##   Scaling correction factor                                   1.470
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                     0.785       0.794
##   Tucker-Lewis Index (TLI)                        0.742       0.753
##
##   Robust Comparative Fit Index (CFI)                          0.796
##   Robust Tucker-Lewis Index (TLI)                             0.756
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -3135.572   -3135.572
##   Scaling correction factor                                  1.266
##       for the MLR correction
##   Loglikelihood unrestricted model (H1)      -2900.260   -2900.260
##   Scaling correction factor                                  1.384
##       for the MLR correction
##
##   Akaike (AIC)                                6349.143    6349.143
##   Bayesian (BIC)                              6481.848    6481.848
##   Sample-size adjusted Bayesian (BIC)         6358.253    6358.253
```

```
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.168       0.134
##   90 Percent confidence interval - lower         0.154       0.122
##   90 Percent confidence interval - upper         0.182       0.146
##   P-value RMSEA <= 0.05                          0.000       0.000
##
##   Robust RMSEA                                                0.161
##   90 Percent confidence interval - lower                      0.144
##   90 Percent confidence interval - upper                      0.179
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.078       0.078
##
## Parameter Estimates:
##
##   Standard errors                             Sandwich
##   Information bread                           Observed
##   Observed information based on                Hessian
##
## Latent Variables:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   gPOP =~
##     POTP1            1.000                               0.589    0.726
##     POTP2            0.953    0.056   16.932    0.000    0.561    0.712
##     POTP3            1.075    0.082   13.068    0.000    0.633    0.696
##     POTP4            0.984    0.073   13.420    0.000    0.579    0.658
##     POTP5            1.149    0.130    8.865    0.000    0.676    0.744
##     POTP6            1.240    0.138    8.968    0.000    0.730    0.786
##     POTP7            1.289    0.180    7.175    0.000    0.758    0.767
##     POTP8            1.194    0.151    7.918    0.000    0.703    0.753
##     POTP9            1.262    0.164    7.700    0.000    0.743    0.730
##     POTP10           1.212    0.172    7.027    0.000    0.713    0.689
##     POTP11           1.400    0.172    8.161    0.000    0.824    0.791
##     POTP12           1.077    0.137    7.881    0.000    0.634    0.675
##     POTP13           0.826    0.137    6.053    0.000    0.486    0.498
##
## Intercepts:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .POTP1            3.009    0.054   55.287    0.000    3.009    3.711
##    .POTP2            3.027    0.053   57.238    0.000    3.027    3.842
##    .POTP3            2.844    0.061   46.524    0.000    2.844    3.128
##    .POTP4            3.099    0.059   52.487    0.000    3.099    3.523
##    .POTP5            2.644    0.061   43.317    0.000    2.644    2.910
##    .POTP6            2.689    0.062   43.135    0.000    2.689    2.895
##    .POTP7            2.382    0.066   35.864    0.000    2.382    2.409
##    .POTP8            2.496    0.063   39.771    0.000    2.496    2.676
##    .POTP9            2.482    0.068   36.377    0.000    2.482    2.441
##    .POTP10           2.250    0.070   32.338    0.000    2.250    2.173
##    .POTP11           2.386    0.070   34.105    0.000    2.386    2.291
##    .POTP12           2.829    0.063   44.915    0.000    2.829    3.014
##    .POTP13           2.673    0.066   40.700    0.000    2.673    2.739
```

```
##     gPOP              0.000                                0.000    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .POTP1             0.311    0.056    5.593    0.000    0.311    0.473
##    .POTP2             0.306    0.052    5.939    0.000    0.306    0.493
##    .POTP3             0.426    0.067    6.380    0.000    0.426    0.516
##    .POTP4             0.439    0.066    6.699    0.000    0.439    0.567
##    .POTP5             0.369    0.052    7.054    0.000    0.369    0.447
##    .POTP6             0.330    0.044    7.423    0.000    0.330    0.382
##    .POTP7             0.402    0.060    6.681    0.000    0.402    0.412
##    .POTP8             0.376    0.058    6.472    0.000    0.376    0.432
##    .POTP9             0.482    0.060    7.970    0.000    0.482    0.467
##    .POTP10            0.563    0.064    8.738    0.000    0.563    0.526
##    .POTP11            0.406    0.060    6.770    0.000    0.406    0.374
##    .POTP12            0.479    0.058    8.325    0.000    0.479    0.544
##    .POTP13            0.716    0.070   10.166    0.000    0.716    0.752
##     gPOP              0.346    0.084    4.128    0.000    1.000    1.000
##
## R-Square:
##                    Estimate
##     POTP1              0.527
##     POTP2              0.507
##     POTP3              0.484
##     POTP4              0.433
##     POTP5              0.553
##     POTP6              0.618
##     POTP7              0.588
##     POTP8              0.568
##     POTP9              0.533
##     POTP10             0.474
##     POTP11             0.626
##     POTP12             0.456
##     POTP13             0.248
```

```
## Parameter estimates
parameterEstimates(pop.cfa1.fit)
```

```
##       lhs op    rhs   est    se      z pvalue ci.lower ci.upper
## 1    gPOP =~  POTP1 1.000 0.000     NA     NA    1.000    1.000
## 2    gPOP =~  POTP2 0.953 0.056 16.932      0    0.843    1.064
## 3    gPOP =~  POTP3 1.075 0.082 13.068      0    0.914    1.236
## 4    gPOP =~  POTP4 0.984 0.073 13.420      0    0.840    1.127
## 5    gPOP =~  POTP5 1.149 0.130  8.865      0    0.895    1.403
## 6    gPOP =~  POTP6 1.240 0.138  8.968      0    0.969    1.512
## 7    gPOP =~  POTP7 1.289 0.180  7.175      0    0.937    1.641
## 8    gPOP =~  POTP8 1.194 0.151  7.918      0    0.898    1.490
## 9    gPOP =~  POTP9 1.262 0.164  7.700      0    0.940    1.583
## 10   gPOP =~ POTP10 1.212 0.172  7.027      0    0.874    1.550
## 11   gPOP =~ POTP11 1.400 0.172  8.161      0    1.064    1.736
## 12   gPOP =~ POTP12 1.077 0.137  7.881      0    0.809    1.344
## 13   gPOP =~ POTP13 0.826 0.137  6.053      0    0.559    1.094
## 14  POTP1 ~~  POTP1 0.311 0.056  5.593      0    0.202    0.420
## 15  POTP2 ~~  POTP2 0.306 0.052  5.939      0    0.205    0.407
## 16  POTP3 ~~  POTP3 0.426 0.067  6.380      0    0.295    0.557
```

```
## 17  POTP4 ~~  POTP4 0.439 0.066  6.699      0    0.310    0.567
## 18  POTP5 ~~  POTP5 0.369 0.052  7.054      0    0.266    0.471
## 19  POTP6 ~~  POTP6 0.330 0.044  7.423      0    0.243    0.417
## 20  POTP7 ~~  POTP7 0.402 0.060  6.681      0    0.284    0.520
## 21  POTP8 ~~  POTP8 0.376 0.058  6.472      0    0.262    0.490
## 22  POTP9 ~~  POTP9 0.482 0.060  7.970      0    0.364    0.601
## 23 POTP10 ~~ POTP10 0.563 0.064  8.738      0    0.437    0.690
## 24 POTP11 ~~ POTP11 0.406 0.060  6.770      0    0.288    0.523
## 25 POTP12 ~~ POTP12 0.479 0.058  8.325      0    0.366    0.592
## 26 POTP13 ~~ POTP13 0.716 0.070 10.166      0    0.578    0.854
## 27   gPOP ~~   gPOP 0.346 0.084  4.128      0    0.182    0.511
## 28  POTP1 ~1        3.009 0.054 55.287      0    2.902    3.116
## 29  POTP2 ~1        3.027 0.053 57.238      0    2.923    3.131
## 30  POTP3 ~1        2.844 0.061 46.524      0    2.724    2.964
## 31  POTP4 ~1        3.099 0.059 52.487      0    2.983    3.215
## 32  POTP5 ~1        2.644 0.061 43.317      0    2.525    2.764
## 33  POTP6 ~1        2.689 0.062 43.135      0    2.567    2.811
## 34  POTP7 ~1        2.382 0.066 35.864      0    2.252    2.512
## 35  POTP8 ~1        2.496 0.063 39.771      0    2.373    2.619
## 36  POTP9 ~1        2.482 0.068 36.377      0    2.348    2.616
## 37 POTP10 ~1        2.250 0.070 32.338      0    2.114    2.386
## 38 POTP11 ~1        2.386 0.070 34.105      0    2.249    2.523
## 39 POTP12 ~1        2.829 0.063 44.915      0    2.705    2.952
## 40 POTP13 ~1        2.673 0.066 40.700      0    2.544    2.801
## 41   gPOP ~1        0.000 0.000     NA     NA    0.000    0.000
```

```
## Standardized residuals
resid(pop.cfa1.fit, type="standardized")
```

```
## $type
## [1] "standardized"
##
## $cov
##        POTP1  POTP2  POTP3  POTP4  POTP5  POTP6  POTP7  POTP8  POTP9  POTP10
## POTP1   0.000
## POTP2   4.255  0.000
## POTP3   2.493  2.806 -0.014
## POTP4   3.154  3.194  3.098  0.000
## POTP5  -0.354  0.380  0.042 -1.257  0.046
## POTP6  -0.623 -2.190 -1.335 -1.489  2.512  0.000
## POTP7  -4.610 -4.999 -1.862 -3.161 -1.177  0.580 -0.015
## POTP8  -2.787 -3.287 -3.634 -1.099  0.034  0.507  3.254  0.134
## POTP9  -5.521 -2.646 -2.866 -2.267  0.115 -0.491  1.414  1.962  0.000
## POTP10 -3.788 -4.079 -0.836 -2.637 -0.469 -1.101  2.639  0.624  1.489 -0.005
## POTP11 -3.645 -2.749 -3.870 -1.630 -2.098 -1.277  1.255  1.503  2.314  2.964
## POTP12 -0.679  0.171 -0.258 -0.797  0.472  1.389 -2.004 -4.820  0.581 -0.524
## POTP13 -0.409 -0.492  0.426 -1.531  0.245  1.366 -0.851 -2.106  0.091 -0.585
##        POTP11 POTP12 POTP13
## POTP1
## POTP2
## POTP3
## POTP4
## POTP5
## POTP6
## POTP7
```

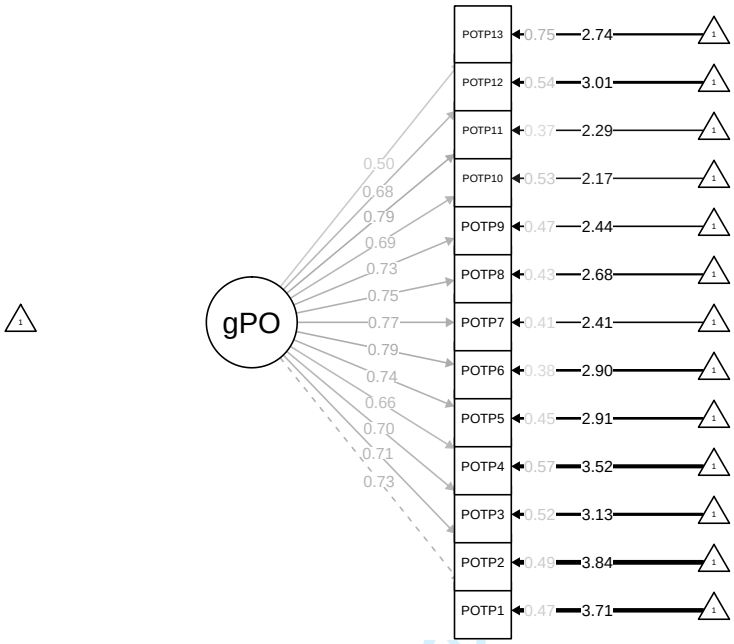
```
## POTP8
## POTP9
## POTP10
## POTP11  0.008
## POTP12  1.269  0.000
## POTP13 -1.128  3.836  0.002
##
## $mean
##  POTP1  POTP2  POTP3  POTP4  POTP5  POTP6  POTP7  POTP8  POTP9 POTP10 POTP11
##  0.000  0.000  0.686  0.000  1.943  0.000  0.886 -2.362  0.000  0.395  1.989
## POTP12 POTP13
##  0.000 -1.192
```

```
## Modification indices
modindices(pop.cfa1.fit)
```

```
##        lhs op    rhs     mi    epc sepc.lv sepc.all sepc.nox
## 42   POTP1 ~~  POTP2 97.858  0.224   0.224    0.725    0.725
## 43   POTP1 ~~  POTP3 33.141  0.153   0.153    0.421    0.421
## 44   POTP1 ~~  POTP4 37.285  0.163   0.163    0.442    0.442
## 45   POTP1 ~~  POTP5  0.125 -0.009  -0.009   -0.026   -0.026
## 46   POTP1 ~~  POTP6  0.426 -0.016  -0.016   -0.049   -0.049
## 47   POTP1 ~~  POTP7 14.332 -0.100  -0.100   -0.284   -0.284
## 48   POTP1 ~~  POTP8  5.743 -0.061  -0.061   -0.179   -0.179
## 49   POTP1 ~~  POTP9 20.844 -0.130  -0.130   -0.337   -0.337
## 50   POTP1 ~~ POTP10  9.509 -0.094  -0.094   -0.225   -0.225
## 51   POTP1 ~~ POTP11  9.509 -0.083  -0.083   -0.234   -0.234
## 52   POTP1 ~~ POTP12  0.700 -0.023  -0.023   -0.061   -0.061
## 53   POTP1 ~~ POTP13  0.234 -0.016  -0.016   -0.034   -0.034
## 54   POTP2 ~~  POTP3 19.946  0.118   0.118    0.325    0.325
## 55   POTP2 ~~  POTP4 37.937  0.163   0.163    0.444    0.444
## 56   POTP2 ~~  POTP5  0.180  0.011   0.011    0.031    0.031
## 57   POTP2 ~~  POTP6  4.612 -0.051  -0.051   -0.161   -0.161
## 58   POTP2 ~~  POTP7 14.294 -0.099  -0.099   -0.282   -0.282
## 59   POTP2 ~~  POTP8 10.685 -0.082  -0.082   -0.243   -0.243
## 60   POTP2 ~~  POTP9  8.650 -0.083  -0.083   -0.216   -0.216
## 61   POTP2 ~~ POTP10 12.691 -0.108  -0.108   -0.259   -0.259
## 62   POTP2 ~~ POTP11  6.575 -0.068  -0.068   -0.194   -0.194
## 63   POTP2 ~~ POTP12  0.043  0.006   0.006    0.015    0.015
## 64   POTP2 ~~ POTP13  0.355 -0.020  -0.020   -0.042   -0.042
## 65   POTP3 ~~  POTP4 36.867  0.189   0.189    0.437    0.437
## 66   POTP3 ~~  POTP5  0.005  0.002   0.002    0.005    0.005
## 67   POTP3 ~~  POTP6  1.951 -0.039  -0.039   -0.105   -0.105
## 68   POTP3 ~~  POTP7  4.506 -0.065  -0.065   -0.158   -0.158
## 69   POTP3 ~~  POTP8  9.341 -0.091  -0.091   -0.227   -0.227
## 70   POTP3 ~~  POTP9  8.386 -0.096  -0.096   -0.212   -0.212
## 71   POTP3 ~~ POTP10  1.023 -0.036  -0.036   -0.073   -0.073
## 72   POTP3 ~~ POTP11 11.853 -0.108  -0.108   -0.259   -0.259
## 73   POTP3 ~~ POTP12  0.170 -0.013  -0.013   -0.030   -0.030
## 74   POTP3 ~~ POTP13  0.357  0.023   0.023    0.042    0.042
## 75   POTP4 ~~  POTP5  2.118 -0.043  -0.043   -0.106   -0.106
## 76   POTP4 ~~  POTP6  3.058 -0.049  -0.049   -0.130   -0.130
## 77   POTP4 ~~  POTP7 11.941 -0.107  -0.107   -0.254   -0.254
## 78   POTP4 ~~  POTP8  1.714 -0.039  -0.039   -0.096   -0.096
## 79   POTP4 ~~  POTP9  4.881 -0.074  -0.074   -0.160   -0.160
```

```
## 80   POTP4 ~~ POTP10  9.765 -0.112  -0.112   -0.225   -0.225
## 81   POTP4 ~~ POTP11  2.187 -0.046  -0.046   -0.110   -0.110
## 82   POTP4 ~~ POTP12  1.078 -0.034  -0.034   -0.074   -0.074
## 83   POTP4 ~~ POTP13  3.660 -0.075  -0.075   -0.134   -0.134
## 84   POTP5 ~~  POTP6 20.873  0.121   0.121    0.348    0.348
## 85   POTP5 ~~  POTP7  2.152 -0.043  -0.043   -0.111   -0.111
## 86   POTP5 ~~  POTP8  0.045 -0.006  -0.006   -0.016   -0.016
## 87   POTP5 ~~  POTP9  0.013  0.004   0.004    0.009    0.009
## 88   POTP5 ~~ POTP10  0.371 -0.020  -0.020   -0.045   -0.045
## 89   POTP5 ~~ POTP11  4.898 -0.066  -0.066   -0.170   -0.170
## 90   POTP5 ~~ POTP12  0.349  0.018   0.018    0.043    0.043
## 91   POTP5 ~~ POTP13  0.066  0.009   0.009    0.018    0.018
## 92   POTP6 ~~  POTP7  0.576  0.021   0.021    0.058    0.058
## 93   POTP6 ~~  POTP8  0.114  0.009   0.009    0.026    0.026
## 94   POTP6 ~~  POTP9  0.343 -0.018  -0.018   -0.044   -0.044
## 95   POTP6 ~~ POTP10  1.617 -0.041  -0.041   -0.095   -0.095
## 96   POTP6 ~~ POTP11  2.184 -0.042  -0.042   -0.115   -0.115
## 97   POTP6 ~~ POTP12  5.466  0.069   0.069    0.174    0.174
## 98   POTP6 ~~ POTP13  2.835  0.059   0.059    0.122    0.122
## 99   POTP7 ~~  POTP8 52.213  0.214   0.214    0.550    0.550
## 100  POTP7 ~~  POTP9  4.238  0.068   0.068    0.155    0.155
## 101  POTP7 ~~ POTP10 14.286  0.134   0.134    0.281    0.281
## 102  POTP7 ~~ POTP11  3.806  0.061   0.061    0.151    0.151
## 103  POTP7 ~~ POTP12  5.568 -0.077  -0.077   -0.174   -0.174
## 104  POTP7 ~~ POTP13  0.878 -0.036  -0.036   -0.068   -0.068
## 105  POTP8 ~~  POTP9  8.337  0.092   0.092    0.216    0.216
## 106  POTP8 ~~ POTP10  0.432  0.022   0.022    0.049    0.049
## 107  POTP8 ~~ POTP11  4.695  0.065   0.065    0.167    0.167
## 108  POTP8 ~~ POTP12 17.337 -0.130  -0.130   -0.307   -0.307
## 109  POTP8 ~~ POTP13  4.225 -0.077  -0.077   -0.148   -0.148
## 110  POTP9 ~~ POTP10  3.975  0.076   0.076    0.146    0.146
## 111  POTP9 ~~ POTP11 15.027  0.130   0.130    0.295    0.295
## 112  POTP9 ~~ POTP12  0.543  0.026   0.026    0.054    0.054
## 113  POTP9 ~~ POTP13  0.011  0.004   0.004    0.007    0.007
## 114 POTP10 ~~ POTP11 27.446  0.188   0.188    0.394    0.394
## 115 POTP10 ~~ POTP12  0.446 -0.025  -0.025   -0.048   -0.048
## 116 POTP10 ~~ POTP13  0.420 -0.029  -0.029   -0.046   -0.046
## 117 POTP11 ~~ POTP12  3.323  0.060   0.060    0.136    0.136
## 118 POTP11 ~~ POTP13  1.690 -0.051  -0.051   -0.095   -0.095
## 119 POTP12 ~~ POTP13 34.373  0.241   0.241    0.412    0.412
```

```r
## Visualize the path model
semPaths(pop.cfa1.fit,
         rotation = 2,
         layout = "tree2",
         what = "std",
         posCol = "black",
         edge.width = 0.5,
         style = "Lisrel",
         fade = T,
         edge.label.position = 0.55)
```




```
## Model specification
## Three factors
pop.cfa3 <- '
              # POP Clarity
              POPCLA =~ POTP1+POTP2+POTP3+POTP4

              # POP Feedback
              POPFED =~ POTP5+POTP6+POTP12+POTP13

              # POP General Instruction
              POPGEN =~ POTP7+POTP8+POTP9+POTP10+POTP11

              # Residual covariance


'

## Model estimation
pop.cfa3.fit <- sem(pop.cfa3, data = pop[,-1],
                    missing = "FIML",
                    estimator = "MLR",
                    se="robust.mlr")

## Summary
summary(pop.cfa3.fit,
        rsquare = TRUE,
        fit.measures = TRUE,
        standardized = TRUE)
```

```
## lavaan 0.6-6 ended normally after 57 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         42
```

```
##
##   Number of observations                           222
##   Number of missing patterns                         8
##
## Model Test User Model:
##                                                Standard      Robust
##   Test Statistic                                154.753     108.475
##   Degrees of freedom                                 62          62
##   P-value (Chi-square)                            0.000       0.000
##   Scaling correction factor                                   1.427
##        Yuan-Bentler correction (Mplus variant)
##
## Model Test Baseline Model:
##
##   Test statistic                              1961.206    1334.000
##   Degrees of freedom                                 78          78
##   P-value                                         0.000       0.000
##   Scaling correction factor                                   1.470
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                     0.951       0.963
##   Tucker-Lewis Index (TLI)                        0.938       0.953
##
##   Robust Comparative Fit Index (CFI)                          0.964
##   Robust Tucker-Lewis Index (TLI)                             0.955
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)               -2977.637   -2977.637
##   Scaling correction factor                                   1.322
##       for the MLR correction
##   Loglikelihood unrestricted model (H1)       -2900.260   -2900.260
##   Scaling correction factor                                   1.384
##       for the MLR correction
##
##   Akaike (AIC)                                6039.274    6039.274
##   Bayesian (BIC)                              6182.187    6182.187
##   Sample-size adjusted Bayesian (BIC)         6049.085    6049.085
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.082       0.058
##   90 Percent confidence interval - lower         0.066       0.043
##   90 Percent confidence interval - upper         0.098       0.073
##   P-value RMSEA <= 0.05                          0.001       0.184
##
##   Robust RMSEA                                                0.069
##   90 Percent confidence interval - lower                      0.047
##   90 Percent confidence interval - upper                      0.091
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.038       0.038
```

```
##
## Parameter Estimates:
##
##   Standard errors                             Sandwich
##   Information bread                           Observed
##   Observed information based on                Hessian
##
## Latent Variables:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   POPCLA =~
##     POTP1            1.000                               0.729    0.900
##     POTP2            0.946    0.052   18.357    0.000    0.690    0.876
##     POTP3            0.960    0.072   13.302    0.000    0.700    0.771
##     POTP4            0.934    0.064   14.555    0.000    0.681    0.774
##   POPFED =~
##     POTP5            1.000                               0.719    0.790
##     POTP6            1.104    0.076   14.569    0.000    0.793    0.854
##     POTP12           0.936    0.099    9.414    0.000    0.673    0.717
##     POTP13           0.745    0.121    6.156    0.000    0.535    0.549
##   POPGEN =~
##     POTP7            1.000                               0.827    0.836
##     POTP8            0.919    0.053   17.458    0.000    0.760    0.814
##     POTP9            0.953    0.075   12.722    0.000    0.788    0.775
##     POTP10           0.932    0.073   12.823    0.000    0.770    0.744
##     POTP11           1.050    0.078   13.506    0.000    0.868    0.833
##
## Covariances:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   POPCLA ~~
##     POPFED           0.385    0.067    5.709    0.000    0.735    0.735
##     POPGEN           0.391    0.065    5.998    0.000    0.648    0.648
##   POPFED ~~
##     POPGEN           0.495    0.075    6.638    0.000    0.834    0.834
##
## Intercepts:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .POTP1            3.009    0.054   55.288    0.000    3.009    3.711
##    .POTP2            3.027    0.053   57.238    0.000    3.027    3.842
##    .POTP3            2.846    0.061   46.636    0.000    2.846    3.134
##    .POTP4            3.099    0.059   52.487    0.000    3.099    3.523
##    .POTP5            2.645    0.061   43.320    0.000    2.645    2.910
##    .POTP6            2.689    0.062   43.135    0.000    2.689    2.895
##    .POTP12           2.829    0.063   44.915    0.000    2.829    3.014
##    .POTP13           2.672    0.066   40.690    0.000    2.672    2.738
##    .POTP7            2.383    0.066   35.880    0.000    2.383    2.410
##    .POTP8            2.497    0.063   39.770    0.000    2.497    2.676
##    .POTP9            2.482    0.068   36.377    0.000    2.482    2.441
##    .POTP10           2.251    0.070   32.352    0.000    2.251    2.174
##    .POTP11           2.387    0.070   34.123    0.000    2.387    2.291
##     POPCLA           0.000                               0.000    0.000
##     POPFED           0.000                               0.000    0.000
##     POPGEN           0.000                               0.000    0.000
##
## Variances:
```

```
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .POTP1             0.125    0.027    4.606    0.000    0.125    0.191
##    .POTP2             0.144    0.038    3.832    0.000    0.144    0.232
##    .POTP3             0.334    0.057    5.858    0.000    0.334    0.405
##    .POTP4             0.310    0.043    7.258    0.000    0.310    0.401
##    .POTP5             0.310    0.046    6.769    0.000    0.310    0.375
##    .POTP6             0.234    0.039    5.987    0.000    0.234    0.271
##    .POTP12            0.428    0.060    7.089    0.000    0.428    0.486
##    .POTP13            0.666    0.071    9.324    0.000    0.666    0.699
##    .POTP7             0.294    0.051    5.751    0.000    0.294    0.301
##    .POTP8             0.293    0.049    6.018    0.000    0.293    0.337
##    .POTP9             0.413    0.054    7.692    0.000    0.413    0.399
##    .POTP10            0.479    0.058    8.300    0.000    0.479    0.447
##    .POTP11            0.332    0.055    6.076    0.000    0.332    0.306
##     POPCLA            0.532    0.081    6.544    0.000    1.000    1.000
##     POPFED            0.516    0.082    6.265    0.000    1.000    1.000
##     POPGEN            0.683    0.090    7.617    0.000    1.000    1.000
##
## R-Square:
##                    Estimate
##     POTP1             0.809
##     POTP2             0.768
##     POTP3             0.595
##     POTP4             0.599
##     POTP5             0.625
##     POTP6             0.729
##     POTP12            0.514
##     POTP13            0.301
##     POTP7             0.699
##     POTP8             0.663
##     POTP9             0.601
##     POTP10            0.553
##     POTP11            0.694
```

```
## Parameter estimates
parameterEstimates(pop.cfa3.fit)
```

```
##       lhs op    rhs   est    se      z pvalue ci.lower ci.upper
## 1  POPCLA =~  POTP1 1.000 0.000     NA     NA    1.000    1.000
## 2  POPCLA =~  POTP2 0.946 0.052 18.357      0    0.845    1.048
## 3  POPCLA =~  POTP3 0.960 0.072 13.302      0    0.819    1.102
## 4  POPCLA =~  POTP4 0.934 0.064 14.555      0    0.808    1.059
## 5  POPFED =~  POTP5 1.000 0.000     NA     NA    1.000    1.000
## 6  POPFED =~  POTP6 1.104 0.076 14.569      0    0.955    1.252
## 7  POPFED =~ POTP12 0.936 0.099  9.414      0    0.741    1.131
## 8  POPFED =~ POTP13 0.745 0.121  6.156      0    0.508    0.982
## 9  POPGEN =~  POTP7 1.000 0.000     NA     NA    1.000    1.000
## 10 POPGEN =~  POTP8 0.919 0.053 17.458      0    0.816    1.023
## 11 POPGEN =~  POTP9 0.953 0.075 12.722      0    0.806    1.100
## 12 POPGEN =~ POTP10 0.932 0.073 12.823      0    0.789    1.074
## 13 POPGEN =~ POTP11 1.050 0.078 13.506      0    0.898    1.202
## 14  POTP1 ~~  POTP1 0.125 0.027  4.606      0    0.072    0.179
## 15  POTP2 ~~  POTP2 0.144 0.038  3.832      0    0.070    0.218
## 16  POTP3 ~~  POTP3 0.334 0.057  5.858      0    0.223    0.446
## 17  POTP4 ~~  POTP4 0.310 0.043  7.258      0    0.226    0.394
```

```
## 18  POTP5 ~~  POTP5 0.310 0.046  6.769      0    0.220    0.400
## 19  POTP6 ~~  POTP6 0.234 0.039  5.987      0    0.157    0.310
## 20 POTP12 ~~ POTP12 0.428 0.060  7.089      0    0.310    0.546
## 21 POTP13 ~~ POTP13 0.666 0.071  9.324      0    0.526    0.806
## 22  POTP7 ~~  POTP7 0.294 0.051  5.751      0    0.194    0.394
## 23  POTP8 ~~  POTP8 0.293 0.049  6.018      0    0.198    0.389
## 24  POTP9 ~~  POTP9 0.413 0.054  7.692      0    0.308    0.518
## 25 POTP10 ~~ POTP10 0.479 0.058  8.300      0    0.366    0.593
## 26 POTP11 ~~ POTP11 0.332 0.055  6.076      0    0.225    0.439
## 27 POPCLA ~~ POPCLA 0.532 0.081  6.544      0    0.373    0.691
## 28 POPFED ~~ POPFED 0.516 0.082  6.265      0    0.355    0.678
## 29 POPGEN ~~ POPGEN 0.683 0.090  7.617      0    0.507    0.859
## 30 POPCLA ~~ POPFED 0.385 0.067  5.709      0    0.253    0.517
## 31 POPCLA ~~ POPGEN 0.391 0.065  5.998      0    0.263    0.518
## 32 POPFED ~~ POPGEN 0.495 0.075  6.638      0    0.349    0.642
## 33  POTP1 ~1        3.009 0.054 55.288      0    2.902    3.116
## 34  POTP2 ~1        3.027 0.053 57.238      0    2.923    3.131
## 35  POTP3 ~1        2.846 0.061 46.636      0    2.727    2.966
## 36  POTP4 ~1        3.099 0.059 52.487      0    2.983    3.215
## 37  POTP5 ~1        2.645 0.061 43.320      0    2.525    2.765
## 38  POTP6 ~1        2.689 0.062 43.135      0    2.567    2.811
## 39 POTP12 ~1        2.829 0.063 44.915      0    2.705    2.952
## 40 POTP13 ~1        2.672 0.066 40.690      0    2.543    2.801
## 41  POTP7 ~1        2.383 0.066 35.880      0    2.252    2.513
## 42  POTP8 ~1        2.497 0.063 39.770      0    2.374    2.620
## 43  POTP9 ~1        2.482 0.068 36.377      0    2.348    2.616
## 44 POTP10 ~1        2.251 0.070 32.352      0    2.114    2.387
## 45 POTP11 ~1        2.387 0.070 34.123      0    2.250    2.524
## 46 POPCLA ~1        0.000 0.000     NA     NA    0.000    0.000
## 47 POPFED ~1        0.000 0.000     NA     NA    0.000    0.000
## 48 POPGEN ~1        0.000 0.000     NA     NA    0.000    0.000
```

```
## Standardized residuals
resid(pop.cfa3.fit, type="standardized")
```

```
## $type
## [1] "standardized"
##
## $cov
##        POTP1  POTP2  POTP3  POTP4  POTP5  POTP6  POTP12 POTP13 POTP7  POTP8
## POTP1   0.000
## POTP2   1.387  0.000
## POTP3  -0.811 -2.472  0.005
## POTP4  -1.239 -0.273  1.574  0.000
## POTP5   0.216  0.807  1.420 -0.098  0.025
## POTP6  -0.329 -1.074  0.509 -0.400  0.932  0.000
## POTP12 -0.223  0.592  0.948  0.005 -1.801 -0.833  0.000
## POTP13 -0.376 -0.392  1.096 -1.073 -1.721 -0.874  3.010  0.000
## POTP7  -0.881 -0.923  1.028 -0.346 -0.447  0.718 -1.100 -0.781 -0.010
## POTP8   0.311 -0.355  0.647  1.358  0.669  0.780 -2.555 -1.671  1.637  0.205
## POTP9  -1.270 -0.133  0.641  0.429  0.871  0.225  1.083  0.284 -1.609  0.065
## POTP10 -0.780 -1.005  1.423 -0.517  0.108 -0.573 -0.034 -0.436  0.434 -2.531
## POTP11  0.301  0.631  0.901  1.482 -0.456 -0.117  1.823 -0.689 -2.887 -1.362
##        POTP9  POTP10 POTP11
## POTP1
```

```
## POTP2
## POTP3
## POTP4
## POTP5
## POTP6
## POTP12
## POTP13
## POTP7
## POTP8
## POTP9   0.000
## POTP10 -0.392 -0.015
## POTP11  1.069  1.814 -0.003
##
## $mean
##  POTP1  POTP2  POTP3  POTP4  POTP5  POTP6 POTP12 POTP13  POTP7  POTP8  POTP9
##  0.000  0.000 -0.611  0.000  0.646  0.000  0.000 -0.520  0.122 -2.482  0.000
## POTP10 POTP11
## -0.584  0.683
```

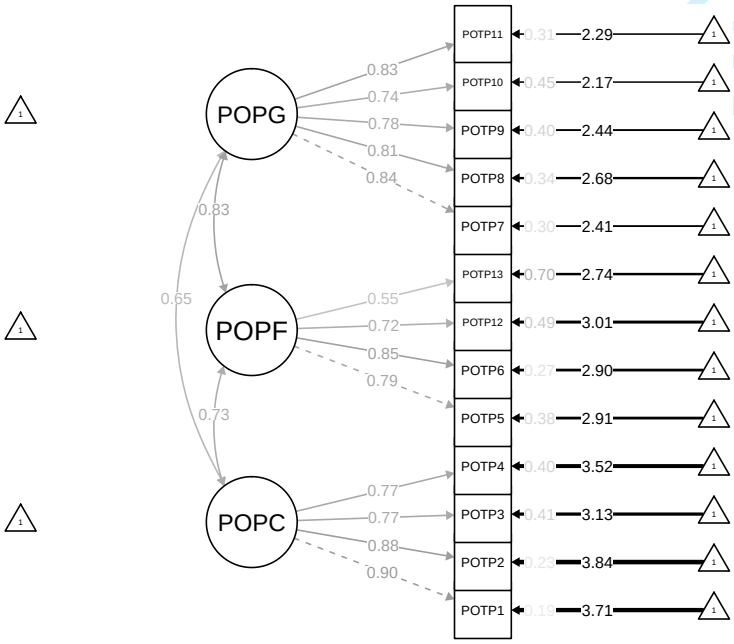
```
## Modification indices
modindices(pop.cfa3.fit)
```

```
##        lhs op    rhs     mi    epc sepc.lv sepc.all sepc.nox
## 49  POPCLA =~  POTP5  1.405  0.132   0.096    0.106    0.106
## 50  POPCLA =~  POTP6  1.519 -0.140  -0.102   -0.110   -0.110
## 51  POPCLA =~ POTP12  0.257  0.060   0.044    0.047    0.047
## 52  POPCLA =~ POTP13  0.242 -0.067  -0.049   -0.050   -0.050
## 53  POPCLA =~  POTP7  0.605 -0.067  -0.049   -0.050   -0.050
## 54  POPCLA =~  POTP8  0.122  0.029   0.021    0.023    0.023
## 55  POPCLA =~  POTP9  0.201 -0.043  -0.031   -0.031   -0.031
## 56  POPCLA =~ POTP10  0.401 -0.064  -0.047   -0.045   -0.045
## 57  POPCLA =~ POTP11  1.815  0.123   0.090    0.086    0.086
## 58  POPFED =~  POTP1  0.580 -0.063  -0.045   -0.056   -0.056
## 59  POPFED =~  POTP2  0.380 -0.050  -0.036   -0.045   -0.045
## 60  POPFED =~  POTP3  4.521  0.223   0.160    0.176    0.176
## 61  POPFED =~  POTP4  0.106 -0.033  -0.024   -0.027   -0.027
## 62  POPFED =~  POTP7  0.422 -0.097  -0.070   -0.071   -0.071
## 63  POPFED =~  POTP8  0.406 -0.092  -0.066   -0.071   -0.071
## 64  POPFED =~  POTP9  1.209  0.180   0.129    0.127    0.127
## 65  POPFED =~ POTP10  0.398 -0.109  -0.078   -0.075   -0.075
## 66  POPFED =~ POTP11  0.660  0.129   0.092    0.089    0.089
## 67  POPGEN =~  POTP1  1.347 -0.068  -0.056   -0.069   -0.069
## 68  POPGEN =~  POTP2  0.590 -0.044  -0.037   -0.046   -0.046
## 69  POPGEN =~  POTP3  3.617  0.144   0.119    0.131    0.131
## 70  POPGEN =~  POTP4  0.430  0.048   0.039    0.045    0.045
## 71  POPGEN =~  POTP5  0.063  0.036   0.030    0.033    0.033
## 72  POPGEN =~  POTP6  0.546  0.112   0.092    0.099    0.099
## 73  POPGEN =~ POTP12  0.054 -0.035  -0.029   -0.031   -0.031
## 74  POPGEN =~ POTP13  1.634 -0.214  -0.177   -0.181   -0.181
## 75   POTP1 ~~  POTP2 14.094  0.081   0.081    0.603    0.603
## 76   POTP1 ~~  POTP3  1.288 -0.026  -0.026   -0.125   -0.125
## 77   POTP1 ~~  POTP4  3.818 -0.043  -0.043   -0.217   -0.217
## 78   POTP1 ~~  POTP5  0.190 -0.008  -0.008   -0.040   -0.040
## 79   POTP1 ~~  POTP6  1.471  0.021   0.021    0.122    0.122
## 80   POTP1 ~~ POTP12  0.864 -0.019  -0.019   -0.082   -0.082
```

```
##  81   POTP1 ~~ POTP13  0.000  0.000   0.000    0.000    0.000
##  82   POTP1 ~~  POTP7  0.027 -0.003  -0.003   -0.015   -0.015
##  83   POTP1 ~~  POTP8  0.988  0.017   0.017    0.091    0.091
##  84   POTP1 ~~  POTP9  4.281 -0.042  -0.042   -0.183   -0.183
##  85   POTP1 ~~ POTP10  0.000  0.000   0.000    0.001    0.001
##  86   POTP1 ~~ POTP11  0.002 -0.001  -0.001   -0.004   -0.004
##  87   POTP2 ~~  POTP3  8.506 -0.064  -0.064   -0.291   -0.291
##  88   POTP2 ~~  POTP4  0.209 -0.010  -0.010   -0.046   -0.046
##  89   POTP2 ~~  POTP5  1.734  0.024   0.024    0.115    0.115
##  90   POTP2 ~~  POTP6  3.898 -0.034  -0.034   -0.187   -0.187
##  91   POTP2 ~~ POTP12  1.450  0.025   0.025    0.101    0.101
##  92   POTP2 ~~ POTP13  0.015 -0.003  -0.003   -0.010   -0.010
##  93   POTP2 ~~  POTP7  0.162 -0.007  -0.007   -0.035   -0.035
##  94   POTP2 ~~  POTP8  0.805 -0.016  -0.016   -0.077   -0.077
##  95   POTP2 ~~  POTP9  0.760  0.018   0.018    0.073    0.073
##  96   POTP2 ~~ POTP10  1.110 -0.023  -0.023   -0.087   -0.087
##  97   POTP2 ~~ POTP11  0.573  0.015   0.015    0.066    0.066
##  98   POTP3 ~~  POTP4  9.713  0.082   0.082    0.253    0.253
##  99   POTP3 ~~  POTP5  0.537  0.019   0.019    0.058    0.058
## 100   POTP3 ~~  POTP6  0.094 -0.007  -0.007   -0.026   -0.026
## 101   POTP3 ~~ POTP12  0.171  0.012   0.012    0.032    0.032
## 102   POTP3 ~~ POTP13  1.619  0.044   0.044    0.094    0.094
## 103   POTP3 ~~  POTP7  1.201  0.028   0.028    0.088    0.088
## 104   POTP3 ~~  POTP8  0.773 -0.022  -0.022   -0.069   -0.069
## 105   POTP3 ~~  POTP9  0.000  0.000   0.000    0.001    0.001
## 106   POTP3 ~~ POTP10  3.720  0.059   0.059    0.146    0.146
## 107   POTP3 ~~ POTP11  0.865 -0.025  -0.025   -0.074   -0.074
## 108   POTP4 ~~  POTP5  0.541 -0.018  -0.018   -0.058   -0.058
## 109   POTP4 ~~  POTP6  0.005  0.002   0.002    0.006    0.006
## 110   POTP4 ~~ POTP12  0.023 -0.004  -0.004   -0.011   -0.011
## 111   POTP4 ~~ POTP13  2.251 -0.050  -0.050   -0.110   -0.110
## 112   POTP4 ~~  POTP7  0.920 -0.023  -0.023   -0.077   -0.077
## 113   POTP4 ~~  POTP8  1.888  0.033   0.033    0.108    0.108
## 114   POTP4 ~~  POTP9  0.520  0.020   0.020    0.055    0.055
## 115   POTP4 ~~ POTP10  0.994 -0.029  -0.029   -0.076   -0.076
## 116   POTP4 ~~ POTP11  1.539  0.032   0.032    0.099    0.099
## 117   POTP5 ~~  POTP6  3.640  0.063   0.063    0.233    0.233
## 118   POTP5 ~~ POTP12  4.466 -0.067  -0.067   -0.185   -0.185
## 119   POTP5 ~~ POTP13  3.376 -0.067  -0.067   -0.146   -0.146
## 120   POTP5 ~~  POTP7  0.609 -0.020  -0.020   -0.066   -0.066
## 121   POTP5 ~~  POTP8  1.460  0.030   0.030    0.100    0.100
## 122   POTP5 ~~  POTP9  0.836  0.026   0.026    0.073    0.073
## 123   POTP5 ~~ POTP10  0.190  0.013   0.013    0.035    0.035
## 124   POTP5 ~~ POTP11  1.890 -0.037  -0.037   -0.115   -0.115
## 125   POTP6 ~~ POTP12  1.114 -0.034  -0.034   -0.108   -0.108
## 126   POTP6 ~~ POTP13  0.862 -0.033  -0.033   -0.082   -0.082
## 127   POTP6 ~~  POTP7  3.493  0.045   0.045    0.170    0.170
## 128   POTP6 ~~  POTP8  2.283  0.035   0.035    0.135    0.135
## 129   POTP6 ~~  POTP9  0.516 -0.019  -0.019   -0.062   -0.062
## 130   POTP6 ~~ POTP10  0.977 -0.028  -0.028   -0.084   -0.084
## 131   POTP6 ~~ POTP11  1.550 -0.032  -0.032   -0.113   -0.113
## 132  POTP12 ~~ POTP13 27.646  0.211   0.211    0.395    0.395
## 133  POTP12 ~~  POTP7  3.679 -0.055  -0.055   -0.154   -0.154
## 134  POTP12 ~~  POTP8 16.013 -0.112  -0.112   -0.316   -0.316
```

```
## 135 POTP12 ~~  POTP9  2.841  0.054   0.054    0.129    0.129
## 136 POTP12 ~~ POTP10  0.102  0.011   0.011    0.024    0.024
## 137 POTP12 ~~ POTP11 14.190  0.114   0.114    0.302    0.302
## 138 POTP13 ~~  POTP7  0.030 -0.006  -0.006   -0.013   -0.013
## 139 POTP13 ~~  POTP8  2.166 -0.049  -0.049   -0.112   -0.112
## 140 POTP13 ~~  POTP9  0.656  0.031   0.031    0.060    0.060
## 141 POTP13 ~~ POTP10  0.016  0.005   0.005    0.009    0.009
## 142 POTP13 ~~ POTP11  0.197 -0.016  -0.016   -0.034   -0.034
## 143  POTP7 ~~  POTP8 26.268  0.141   0.141    0.481    0.481
## 144  POTP7 ~~  POTP9  3.634 -0.059  -0.059   -0.169   -0.169
## 145  POTP7 ~~ POTP10  0.504  0.023   0.023    0.061    0.061
## 146  POTP7 ~~ POTP11 10.126 -0.097  -0.097   -0.310   -0.310
## 147  POTP8 ~~  POTP9  0.011 -0.003  -0.003   -0.009   -0.009
## 148  POTP8 ~~ POTP10 10.064 -0.099  -0.099   -0.265   -0.265
## 149  POTP8 ~~ POTP11  3.848 -0.057  -0.057   -0.183   -0.183
## 150  POTP9 ~~ POTP10  0.259 -0.018  -0.018   -0.041   -0.041
## 151  POTP9 ~~ POTP11  2.530  0.052   0.052    0.140    0.140
## 152 POTP10 ~~ POTP11 11.302  0.115   0.115    0.288    0.288
```

```r
## Visualize the path model
semPaths(pop.cfa3.fit,
         rotation = 2,
         layout = "tree2",
         what = "std",
         posCol = "black",
         edge.width = 0.5,
         style = "Lisrel",
         fade = T,
         edge.label.position = 0.55)
```




```r
## Model specification
## Three factors modified
pop.cfa3m <- '
              # POP Clarity
```

```
              POPCLA =~ POTP1+POTP2+POTP3+POTP4

              # POP Feedback
              POPFED =~ POTP5+POTP6+POTP12+POTP13

              # POP General Instruction
              POPGEN =~ POTP7+POTP8+POTP9+POTP10+POTP11

              # Residual covariance
              POTP1 ~~  POTP2
              POTP7 ~~  POTP8

'

## Model estimation
pop.cfa3m.fit <- sem(pop.cfa3m, data = pop[,-1],
                     missing = "FIML",
                     estimator = "MLR",
                     se="robust.mlr")

## Summary
summary(pop.cfa3m.fit,
        rsquare = TRUE,
        fit.measures = TRUE,
        standardized = TRUE)
```

```
## lavaan 0.6-6 ended normally after 61 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         44
##
##   Number of observations                           222
##   Number of missing patterns                         8
##
## Model Test User Model:
##                                                   Standard      Robust
##   Test Statistic                                   117.654      84.403
##   Degrees of freedom                                    60          60
##   P-value (Chi-square)                            0.000       0.021
##   Scaling correction factor                                   1.394
##         Yuan-Bentler correction (Mplus variant)
##
## Model Test Baseline Model:
##
##   Test statistic                                1961.206    1334.000
##   Degrees of freedom                                  78          78
##   P-value                                         0.000       0.000
##   Scaling correction factor                                   1.470
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                     0.969       0.981
##   Tucker-Lewis Index (TLI)                        0.960       0.975
```

```
##
##   Robust Comparative Fit Index (CFI)                         0.982
##   Robust Tucker-Lewis Index (TLI)                            0.976
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -2959.087   -2959.087
##   Scaling correction factor                                  1.372
##       for the MLR correction
##   Loglikelihood unrestricted model (H1)      -2900.260   -2900.260
##   Scaling correction factor                                  1.384
##       for the MLR correction
##
##   Akaike (AIC)                                6006.175    6006.175
##   Bayesian (BIC)                              6155.892    6155.892
##   Sample-size adjusted Bayesian (BIC)         6016.453    6016.453
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.066       0.043
##   90 Percent confidence interval - lower         0.048       0.022
##   90 Percent confidence interval - upper         0.083       0.060
##   P-value RMSEA <= 0.05                          0.070       0.737
##
##   Robust RMSEA                                               0.051
##   90 Percent confidence interval - lower                     0.021
##   90 Percent confidence interval - upper                     0.074
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.034       0.034
##
## Parameter Estimates:
##
##   Standard errors                             Sandwich
##   Information bread                           Observed
##   Observed information based on                Hessian
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   POPCLA =~
##     POTP1             1.000                               0.684    0.843
##     POTP2             0.940    0.056   16.639    0.000    0.643    0.816
##     POTP3             1.079    0.095   11.416    0.000    0.738    0.812
##     POTP4             1.033    0.081   12.795    0.000    0.707    0.803
##   POPFED =~
##     POTP5             1.000                               0.716    0.788
##     POTP6             1.101    0.078   14.029    0.000    0.788    0.848
##     POTP12            0.951    0.103    9.250    0.000    0.681    0.726
##     POTP13            0.752    0.124    6.089    0.000    0.539    0.552
##   POPGEN =~
##     POTP7             1.000                               0.783    0.792
##     POTP8             0.914    0.060   15.231    0.000    0.716    0.767
##     POTP9             1.018    0.085   12.002    0.000    0.797    0.784
```

```
##     POTP10            1.001    0.077   12.922    0.000    0.784    0.757
##     POTP11            1.140    0.086   13.272    0.000    0.893    0.857
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .POTP1 ~~
##    .POTP2            0.078    0.030    2.633    0.008    0.078    0.394
##  .POTP7 ~~
##    .POTP8            0.140    0.060    2.344    0.019    0.140    0.387
##   POPCLA ~~
##     POPFED           0.368    0.069    5.345    0.000    0.751    0.751
##     POPGEN           0.361    0.066    5.499    0.000    0.675    0.675
##   POPFED ~~
##     POPGEN           0.472    0.075    6.285    0.000    0.841    0.841
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .POTP1            3.009    0.054   55.287    0.000    3.009    3.711
##    .POTP2            3.027    0.053   57.238    0.000    3.027    3.842
##    .POTP3            2.846    0.061   46.653    0.000    2.846    3.134
##    .POTP4            3.099    0.059   52.487    0.000    3.099    3.523
##    .POTP5            2.645    0.061   43.315    0.000    2.645    2.910
##    .POTP6            2.689    0.062   43.135    0.000    2.689    2.895
##    .POTP12           2.829    0.063   44.915    0.000    2.829    3.014
##    .POTP13           2.672    0.066   40.698    0.000    2.672    2.738
##    .POTP7            2.382    0.066   35.883    0.000    2.382    2.410
##    .POTP8            2.497    0.063   39.782    0.000    2.497    2.676
##    .POTP9            2.482    0.068   36.377    0.000    2.482    2.441
##    .POTP10           2.251    0.070   32.355    0.000    2.251    2.174
##    .POTP11           2.387    0.070   34.126    0.000    2.387    2.291
##     POPCLA           0.000                       0.000    0.000
##     POPFED           0.000                       0.000    0.000
##     POPGEN           0.000                       0.000    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .POTP1            0.190    0.035    5.398    0.000    0.190    0.289
##    .POTP2            0.208    0.043    4.839    0.000    0.208    0.335
##    .POTP3            0.281    0.051    5.459    0.000    0.281    0.340
##    .POTP4            0.275    0.036    7.655    0.000    0.275    0.355
##    .POTP5            0.314    0.048    6.597    0.000    0.314    0.379
##    .POTP6            0.242    0.042    5.815    0.000    0.242    0.280
##    .POTP12           0.417    0.059    7.023    0.000    0.417    0.474
##    .POTP13           0.662    0.071    9.356    0.000    0.662    0.695
##    .POTP7            0.364    0.063    5.758    0.000    0.364    0.372
##    .POTP8            0.358    0.066    5.467    0.000    0.358    0.411
##    .POTP9            0.398    0.056    7.081    0.000    0.398    0.385
##    .POTP10           0.458    0.057    8.010    0.000    0.458    0.427
##    .POTP11           0.289    0.048    6.011    0.000    0.289    0.266
##     POPCLA           0.468    0.084    5.561    0.000    1.000    1.000
##     POPFED           0.513    0.083    6.165    0.000    1.000    1.000
##     POPGEN           0.613    0.091    6.749    0.000    1.000    1.000
##
## R-Square:
```

```
##                    Estimate
##     POTP1             0.711
##     POTP2             0.665
##     POTP3             0.660
##     POTP4             0.645
##     POTP5             0.621
##     POTP6             0.720
##     POTP12            0.526
##     POTP13            0.305
##     POTP7             0.628
##     POTP8             0.589
##     POTP9             0.615
##     POTP10            0.573
##     POTP11            0.734
```

```
## Parameter estimates
parameterEstimates(pop.cfa3m.fit)
```

```
##       lhs op    rhs   est    se      z pvalue ci.lower ci.upper
## 1  POPCLA =~  POTP1 1.000 0.000     NA     NA    1.000    1.000
## 2  POPCLA =~  POTP2 0.940 0.056 16.639  0.000    0.829    1.051
## 3  POPCLA =~  POTP3 1.079 0.095 11.416  0.000    0.894    1.264
## 4  POPCLA =~  POTP4 1.033 0.081 12.795  0.000    0.875    1.192
## 5  POPFED =~  POTP5 1.000 0.000     NA     NA    1.000    1.000
## 6  POPFED =~  POTP6 1.101 0.078 14.029  0.000    0.947    1.254
## 7  POPFED =~ POTP12 0.951 0.103  9.250  0.000    0.749    1.152
## 8  POPFED =~ POTP13 0.752 0.124  6.089  0.000    0.510    0.994
## 9  POPGEN =~  POTP7 1.000 0.000     NA     NA    1.000    1.000
## 10 POPGEN =~  POTP8 0.914 0.060 15.231  0.000    0.796    1.032
## 11 POPGEN =~  POTP9 1.018 0.085 12.002  0.000    0.851    1.184
## 12 POPGEN =~ POTP10 1.001 0.077 12.922  0.000    0.849    1.153
## 13 POPGEN =~ POTP11 1.140 0.086 13.272  0.000    0.971    1.308
## 14  POTP1 ~~  POTP2 0.078 0.030  2.633  0.008    0.020    0.137
## 15  POTP7 ~~  POTP8 0.140 0.060  2.344  0.019    0.023    0.257
## 16  POTP1 ~~  POTP1 0.190 0.035  5.398  0.000    0.121    0.259
## 17  POTP2 ~~  POTP2 0.208 0.043  4.839  0.000    0.124    0.292
## 18  POTP3 ~~  POTP3 0.281 0.051  5.459  0.000    0.180    0.382
## 19  POTP4 ~~  POTP4 0.275 0.036  7.655  0.000    0.204    0.345
## 20  POTP5 ~~  POTP5 0.314 0.048  6.597  0.000    0.220    0.407
## 21  POTP6 ~~  POTP6 0.242 0.042  5.815  0.000    0.160    0.323
## 22 POTP12 ~~ POTP12 0.417 0.059  7.023  0.000    0.301    0.533
## 23 POTP13 ~~ POTP13 0.662 0.071  9.356  0.000    0.523    0.801
## 24  POTP7 ~~  POTP7 0.364 0.063  5.758  0.000    0.240    0.487
## 25  POTP8 ~~  POTP8 0.358 0.066  5.467  0.000    0.230    0.486
## 26  POTP9 ~~  POTP9 0.398 0.056  7.081  0.000    0.288    0.509
## 27 POTP10 ~~ POTP10 0.458 0.057  8.010  0.000    0.346    0.570
## 28 POTP11 ~~ POTP11 0.289 0.048  6.011  0.000    0.195    0.383
## 29 POPCLA ~~ POPCLA 0.468 0.084  5.561  0.000    0.303    0.632
## 30 POPFED ~~ POPFED 0.513 0.083  6.165  0.000    0.350    0.676
## 31 POPGEN ~~ POPGEN 0.613 0.091  6.749  0.000    0.435    0.791
## 32 POPCLA ~~ POPFED 0.368 0.069  5.345  0.000    0.233    0.503
## 33 POPCLA ~~ POPGEN 0.361 0.066  5.499  0.000    0.232    0.490
## 34 POPFED ~~ POPGEN 0.472 0.075  6.285  0.000    0.325    0.619
## 35  POTP1 ~1        3.009 0.054 55.287  0.000    2.902    3.116
## 36  POTP2 ~1        3.027 0.053 57.238  0.000    2.923    3.131
```

```
## 37  POTP3 ~1        2.846 0.061 46.653  0.000    2.727    2.966
## 38  POTP4 ~1        3.099 0.059 52.487  0.000    2.983    3.215
## 39  POTP5 ~1        2.645 0.061 43.315  0.000    2.525    2.765
## 40  POTP6 ~1        2.689 0.062 43.135  0.000    2.567    2.811
## 41 POTP12 ~1        2.829 0.063 44.915  0.000    2.705    2.952
## 42 POTP13 ~1        2.672 0.066 40.698  0.000    2.544    2.801
## 43  POTP7 ~1        2.382 0.066 35.883  0.000    2.252    2.513
## 44  POTP8 ~1        2.497 0.063 39.782  0.000    2.374    2.620
## 45  POTP9 ~1        2.482 0.068 36.377  0.000    2.348    2.616
## 46 POTP10 ~1        2.251 0.070 32.355  0.000    2.114    2.387
## 47 POTP11 ~1        2.387 0.070 34.126  0.000    2.250    2.524
## 48 POPCLA ~1        0.000 0.000     NA     NA    0.000    0.000
## 49 POPFED ~1        0.000 0.000     NA     NA    0.000    0.000
## 50 POPGEN ~1        0.000 0.000     NA     NA    0.000    0.000
```

```
## Standardized residuals
resid(pop.cfa3m.fit, type="standardized")
```

```
## $type
## [1] "standardized"
##
## $cov
##        POTP1  POTP2  POTP3  POTP4  POTP5  POTP6  POTP12 POTP13 POTP7  POTP8
## POTP1   0.000
## POTP2   0.000  0.000
## POTP3  -0.276 -1.676  0.014
## POTP4  -0.166  0.792  0.548  0.000
## POTP5   0.803  1.251  0.870 -0.772  0.025
## POTP6   0.499 -0.321 -0.242 -1.262  1.071  0.000
## POTP12  0.094  0.883  0.298 -0.635 -2.069 -1.174  0.000
## POTP13 -0.102 -0.095  0.605 -1.465 -1.933 -0.858  2.954  0.002
## POTP7   0.141  0.192  0.810 -0.539  0.219  1.453 -0.801 -0.426 -0.013
## POTP8   1.311  0.627  0.394  1.124  1.417  1.589 -2.220 -1.252  0.236  0.350
## POTP9  -1.127  0.048 -0.227 -0.318  0.693 -0.002  0.870  0.094 -0.327  1.017
## POTP10 -0.657 -0.849  0.637 -1.267 -0.159 -0.900 -0.416 -0.666  1.071 -1.447
## POTP11  0.288  0.727 -0.206  0.417 -1.114 -0.863  1.391 -1.108 -1.999 -0.294
##        POTP9  POTP10 POTP11
## POTP1
## POTP2
## POTP3
## POTP4
## POTP5
## POTP6
## POTP12
## POTP13
## POTP7
## POTP8
## POTP9   0.000
## POTP10 -1.313 -0.018
## POTP11  0.155  1.484  0.002
##
## $mean
##  POTP1  POTP2  POTP3  POTP4  POTP5  POTP6 POTP12 POTP13  POTP7  POTP8  POTP9
##  0.000  0.000 -0.766  0.000  0.716  0.000  0.000 -0.767  0.324 -2.817  0.000
## POTP10 POTP11
```

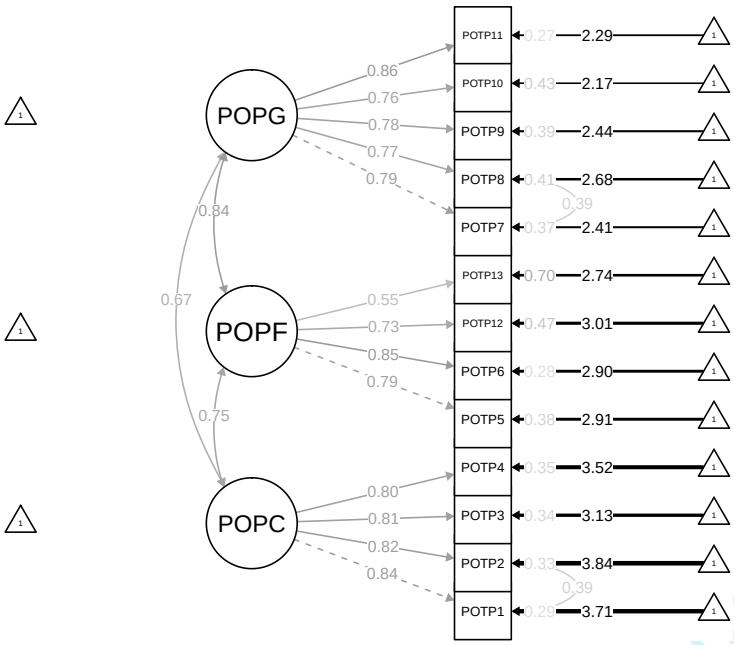
```
## -0.553  0.840
```

```
## Modification indices
modindices(pop.cfa3m.fit)
```

```
##        lhs op    rhs     mi    epc sepc.lv sepc.all sepc.nox
## 51  POPCLA =~  POTP5  1.326  0.149   0.102    0.112    0.112
## 52  POPCLA =~  POTP6  0.945 -0.128  -0.088   -0.094   -0.094
## 53  POPCLA =~ POTP12  0.083  0.040   0.027    0.029    0.029
## 54  POPCLA =~ POTP13  0.345 -0.093  -0.063   -0.065   -0.065
## 55  POPCLA =~  POTP7  0.040 -0.019  -0.013   -0.013   -0.013
## 56  POPCLA =~  POTP8  1.420  0.109   0.074    0.080    0.080
## 57  POPCLA =~  POTP9  0.500 -0.080  -0.055   -0.054   -0.054
## 58  POPCLA =~ POTP10  0.950 -0.115  -0.079   -0.076   -0.076
## 59  POPCLA =~ POTP11  0.212  0.050   0.034    0.033    0.033
## 60  POPFED =~  POTP1  0.134  0.031   0.022    0.027    0.027
## 61  POPFED =~  POTP2  0.440  0.055   0.039    0.050    0.050
## 62  POPFED =~  POTP3  0.520  0.088   0.063    0.069    0.069
## 63  POPFED =~  POTP4  4.322 -0.245  -0.175   -0.199   -0.199
## 64  POPFED =~  POTP7  0.343  0.086   0.061    0.062    0.062
## 65  POPFED =~  POTP8  0.332  0.082   0.059    0.063    0.063
## 66  POPFED =~  POTP9  0.456  0.120   0.086    0.085    0.085
## 67  POPFED =~ POTP10  1.834 -0.250  -0.179   -0.173   -0.173
## 68  POPFED =~ POTP11  0.439 -0.118  -0.085   -0.081   -0.081
## 69  POPGEN =~  POTP1  0.065 -0.016  -0.013   -0.015   -0.015
## 70  POPGEN =~  POTP2  0.230  0.030   0.024    0.030    0.030
## 71  POPGEN =~  POTP3  0.235  0.044   0.035    0.038    0.038
## 72  POPGEN =~  POTP4  0.574 -0.067  -0.052   -0.060   -0.060
## 73  POPGEN =~  POTP5  0.020  0.023   0.018    0.020    0.020
## 74  POPGEN =~  POTP6  0.059  0.041   0.032    0.035    0.035
## 75  POPGEN =~ POTP12  0.218  0.077   0.061    0.065    0.065
## 76  POPGEN =~ POTP13  1.623 -0.237  -0.186   -0.190   -0.190
## 77   POTP1 ~~  POTP3  0.215  0.010   0.010    0.043    0.043
## 78   POTP1 ~~  POTP4  0.461 -0.014  -0.014   -0.062   -0.062
## 79   POTP1 ~~  POTP5  0.120 -0.006  -0.006   -0.026   -0.026
## 80   POTP1 ~~  POTP6  3.270  0.031   0.031    0.143    0.143
## 81   POTP1 ~~ POTP12  0.900 -0.019  -0.019   -0.067   -0.067
## 82   POTP1 ~~ POTP13  0.010  0.002   0.002    0.007    0.007
## 83   POTP1 ~~  POTP7  0.102 -0.005  -0.005   -0.020   -0.020
## 84   POTP1 ~~  POTP8  1.416  0.020   0.020    0.075    0.075
## 85   POTP1 ~~  POTP9  4.012 -0.040  -0.040   -0.144   -0.144
## 86   POTP1 ~~ POTP10  0.072  0.006   0.006    0.019    0.019
## 87   POTP1 ~~ POTP11  0.000  0.000   0.000   -0.001   -0.001
## 88   POTP2 ~~  POTP3  3.010 -0.037  -0.037   -0.152   -0.152
## 89   POTP2 ~~  POTP4  1.401  0.024   0.024    0.101    0.101
## 90   POTP2 ~~  POTP5  2.174  0.027   0.027    0.106    0.106
## 91   POTP2 ~~  POTP6  3.053 -0.030  -0.030   -0.134   -0.134
## 92   POTP2 ~~ POTP12  1.911  0.028   0.028    0.095    0.095
## 93   POTP2 ~~ POTP13  0.005 -0.002  -0.002   -0.005   -0.005
## 94   POTP2 ~~  POTP7  0.001  0.001   0.001    0.002    0.002
## 95   POTP2 ~~  POTP8  0.566 -0.013  -0.013   -0.046   -0.046
## 96   POTP2 ~~  POTP9  1.257  0.023   0.023    0.078    0.078
## 97   POTP2 ~~ POTP10  1.316 -0.024  -0.024   -0.079   -0.079
## 98   POTP2 ~~ POTP11  0.454  0.012   0.012    0.051    0.051
## 99   POTP3 ~~  POTP4  1.256  0.037   0.037    0.135    0.135
```

```
## 100  POTP3 ~~  POTP5  0.416  0.016   0.016    0.055    0.055
## 101  POTP3 ~~  POTP6  0.623 -0.019  -0.019   -0.072   -0.072
## 102  POTP3 ~~ POTP12  0.039  0.006   0.006    0.016    0.016
## 103  POTP3 ~~ POTP13  1.689  0.044   0.044    0.102    0.102
## 104  POTP3 ~~  POTP7  2.139  0.034   0.034    0.107    0.107
## 105  POTP3 ~~  POTP8  1.684 -0.030  -0.030   -0.094   -0.094
## 106  POTP3 ~~  POTP9  0.113 -0.009  -0.009   -0.028   -0.028
## 107  POTP3 ~~ POTP10  3.851  0.057   0.057    0.160    0.160
## 108  POTP3 ~~ POTP11  1.996 -0.036  -0.036   -0.126   -0.126
## 109  POTP4 ~~  POTP5  0.930 -0.024  -0.024   -0.081   -0.081
## 110  POTP4 ~~  POTP6  0.081 -0.007  -0.007   -0.026   -0.026
## 111  POTP4 ~~ POTP12  0.170 -0.011  -0.011   -0.033   -0.033
## 112  POTP4 ~~ POTP13  3.324 -0.060  -0.060   -0.141   -0.141
## 113  POTP4 ~~  POTP7  2.595 -0.037  -0.037   -0.117   -0.117
## 114  POTP4 ~~  POTP8  3.330  0.041   0.041    0.131    0.131
## 115  POTP4 ~~  POTP9  0.255  0.014   0.014    0.041    0.041
## 116  POTP4 ~~ POTP10  2.214 -0.043  -0.043   -0.120   -0.120
## 117  POTP4 ~~ POTP11  1.955  0.035   0.035    0.123    0.123
## 118  POTP5 ~~  POTP6  5.517  0.077   0.077    0.280    0.280
## 119  POTP5 ~~ POTP12  5.636 -0.076  -0.076   -0.210   -0.210
## 120  POTP5 ~~ POTP13  3.518 -0.068  -0.068   -0.150   -0.150
## 121  POTP5 ~~  POTP7  0.641 -0.019  -0.019   -0.058   -0.058
## 122  POTP5 ~~  POTP8  3.012  0.041   0.041    0.123    0.123
## 123  POTP5 ~~  POTP9  0.785  0.026   0.026    0.072    0.072
## 124  POTP5 ~~ POTP10  0.114  0.010   0.010    0.027    0.027
## 125  POTP5 ~~ POTP11  3.224 -0.048  -0.048   -0.159   -0.159
## 126  POTP6 ~~ POTP12  1.619 -0.041  -0.041   -0.131   -0.131
## 127  POTP6 ~~ POTP13  0.824 -0.032  -0.032   -0.080   -0.080
## 128  POTP6 ~~  POTP7  2.996  0.040   0.040    0.134    0.134
## 129  POTP6 ~~  POTP8  1.821  0.030   0.030    0.103    0.103
## 130  POTP6 ~~  POTP9  0.329 -0.016  -0.016   -0.050   -0.050
## 131  POTP6 ~~ POTP10  0.916 -0.027  -0.027   -0.083   -0.083
## 132  POTP6 ~~ POTP11  1.963 -0.036  -0.036   -0.134   -0.134
## 133 POTP12 ~~ POTP13 26.707  0.206   0.206    0.391    0.391
## 134 POTP12 ~~  POTP7  0.288 -0.014  -0.014   -0.037   -0.037
## 135 POTP12 ~~  POTP8 10.111 -0.084  -0.084   -0.218   -0.218
## 136 POTP12 ~~  POTP9  1.068  0.033   0.033    0.081    0.081
## 137 POTP12 ~~ POTP10  0.137 -0.013  -0.013   -0.029   -0.029
## 138 POTP12 ~~ POTP11  9.981  0.093   0.093    0.268    0.268
## 139 POTP13 ~~  POTP7  0.143  0.012   0.012    0.025    0.025
## 140 POTP13 ~~  POTP8  1.577 -0.040  -0.040   -0.083   -0.083
## 141 POTP13 ~~  POTP9  0.409  0.025   0.025    0.048    0.048
## 142 POTP13 ~~ POTP10  0.005 -0.003  -0.003   -0.005   -0.005
## 143 POTP13 ~~ POTP11  0.708 -0.030  -0.030   -0.068   -0.068
## 144  POTP7 ~~  POTP9  0.764 -0.025  -0.025   -0.066   -0.066
## 145  POTP7 ~~ POTP10  6.030  0.074   0.074    0.181    0.181
## 146  POTP7 ~~ POTP11  2.813 -0.047  -0.047   -0.144   -0.144
## 147  POTP8 ~~  POTP9  2.164  0.041   0.041    0.108    0.108
## 148  POTP8 ~~ POTP10  6.326 -0.073  -0.073   -0.181   -0.181
## 149  POTP8 ~~ POTP11  0.014  0.003   0.003    0.010    0.010
## 150  POTP9 ~~ POTP10  1.840 -0.049  -0.049   -0.115   -0.115
## 151  POTP9 ~~ POTP11  0.030  0.006   0.006    0.018    0.018
## 152 POTP10 ~~ POTP11  5.491  0.083   0.083    0.229    0.229
```

```r
## Visualize the path model
semPaths(pop.cfa3m.fit,
         rotation = 2,
         layout = "tree2",
         what = "std",
         posCol = "black",
         edge.width = 0.5,
         style = "Lisrel",
         fade = T,
         edge.label.position = 0.55)
```




```r
## Model comparison
anova(pop.cfa3.fit, pop.cfa3m.fit)
```

```
## Scaled Chi-Squared Difference Test (method = "satorra.bentler.2001")
##
## lavaan NOTE:
##     The "Chisq" column contains standard test statistics, not the
##     robust test that should be reported per model. A robust difference
##     test is a function of two standard (not robust) statistics.
##
##               Df    AIC    BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## pop.cfa3m.fit 60 6006.2 6155.9 117.65
## pop.cfa3.fit  62 6039.3 6182.2 154.75     15.413       2  0.0004498 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

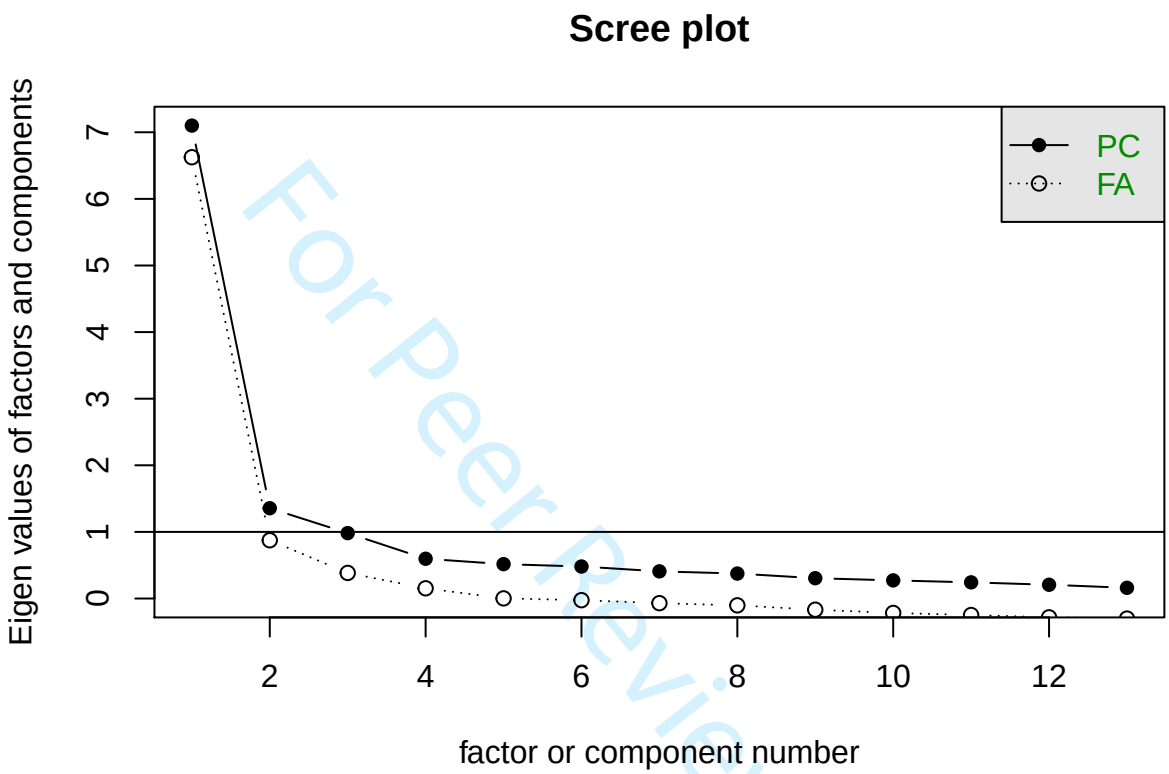
```r
## EFA
## Eigenvalues and scree plot
eval.pop <- eigen(pop.cor)$values
eval.pop
```

```
##  [1] 7.1001620 1.3557023 0.9821296 0.5967497 0.5159998 0.4804131 0.4077296
##  [8] 0.3747611 0.3049298 0.2722088 0.2424113 0.2065299 0.1602731
```

```r
# Ratio of eigenvalues
(eval.pop /sum(eval.pop )*100)[1:4]
```

```
## [1] 54.616630 10.428479  7.554843  4.590382
```

```r
## Screeplot
scree(pop.cor, factors = TRUE)
```

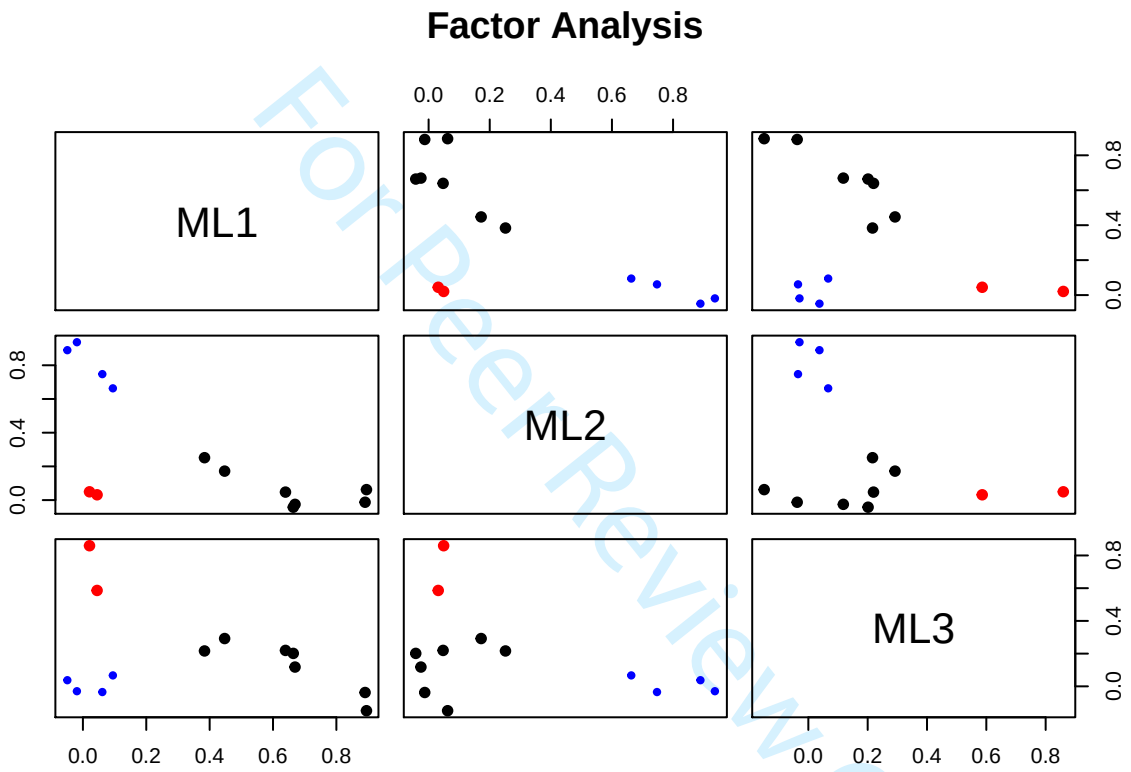



```r
## EFA with oblimin rotation
pop.efa <- fa(pop.cor, nfactors = 3,
              rotate = "oblimin",
              fm = "ml")

# Factor loadings
pop.efa$loadings
```

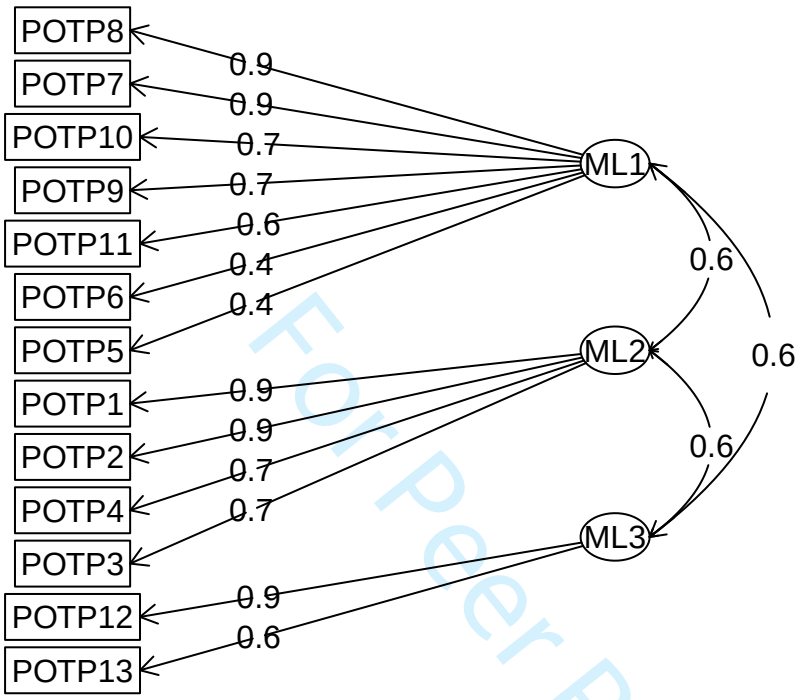
```
##
## Loadings:
##        ML1    ML2    ML3
## POTP1          0.937
## POTP2          0.890
## POTP3          0.663
## POTP4          0.747
## POTP5   0.384  0.252  0.216
## POTP6   0.447  0.172  0.292
## POTP7   0.891
## POTP8   0.895        -0.149
## POTP9   0.664         0.201
## POTP10  0.669         0.118
## POTP11  0.639         0.220
```

```
## POTP12                0.860
## POTP13                0.586
##
##                  ML1   ML2   ML3
## SS loadings    3.257 2.773 1.349
## Proportion Var 0.251 0.213 0.104
## Cumulative Var 0.251 0.464 0.568
```

```
# Factor plot
factor.plot(pop.efa)
```




```
# Factor diagram
fa.diagram(pop.efa)
```



Conclusion Accept the model with robust ML estimation, three POP factors (`POPFED`, `POPCLA`, and `POPGEN`), and two residual covariances. Model `pop.cfa3m` is the final model.

```
## Extract the factor scores
pop.sf <- lavPredict(pop.cfa3m.fit)
head(pop.sf, 5)
```

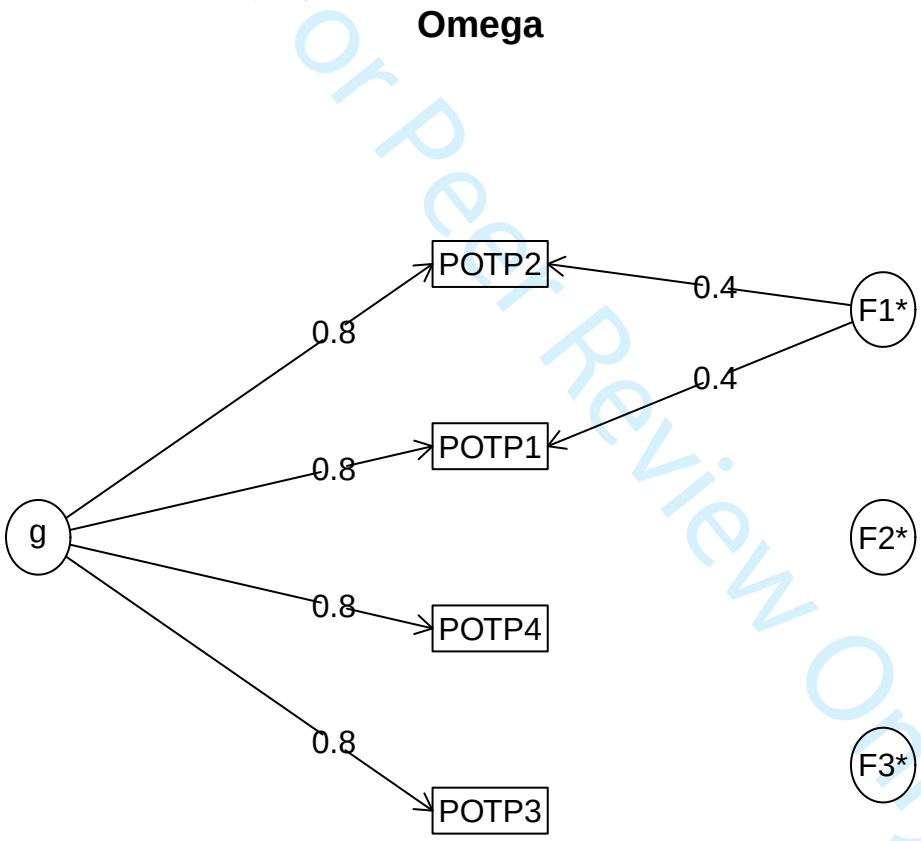
```
##           POPCLA     POPFED      POPGEN
## [1,] -0.40870916 -0.3781949 -0.37726481
## [2,]  0.04469573  0.1678385  0.44953973
## [3,]  0.06474838  0.2943419  0.48244946
## [4,] -0.06414635 -0.2455269 -1.00380215
## [5,]  0.81852216  0.4895920  0.09800701
```

```
## Check by correlating with the sum scores
## Define the sum scores
pop.sum1 <- pop$POTP1+pop$POTP2+pop$POTP3+pop$POTP4
pop.sum2 <- pop$POTP5+pop$POTP6+pop$POTP12+pop$POTP13
pop.sum3 <- pop$POTP7+pop$POTP8+pop$POTP9+pop$POTP10+pop$POTP11

pop.temp <- data.frame(pop.sum1, pop.sum2, pop.sum3,
                       pop.sf)

## Correlation
cor(pop.temp, use = "pairwise.complete.obs")
```

```
##           pop.sum1  pop.sum2  pop.sum3    POPCLA    POPFED    POPGEN
## pop.sum1 1.0000000 0.6329501 0.5930620 0.9914576 0.7470451 0.6658430
## pop.sum2 0.6329501 1.0000000 0.7020772 0.7142560 0.9525428 0.7890814
```

```
## pop.sum3 0.5930620 0.7020772 1.0000000 0.6693661 0.8364650 0.9859751
## POPCLA   0.9914576 0.7142560 0.6693661 1.0000000 0.8233117 0.7433041
## POPFED   0.7470451 0.9525428 0.8364650 0.8233117 1.0000000 0.9071078
## POPGEN   0.6658430 0.7890814 0.9859751 0.7433041 0.9071078 1.0000000
```

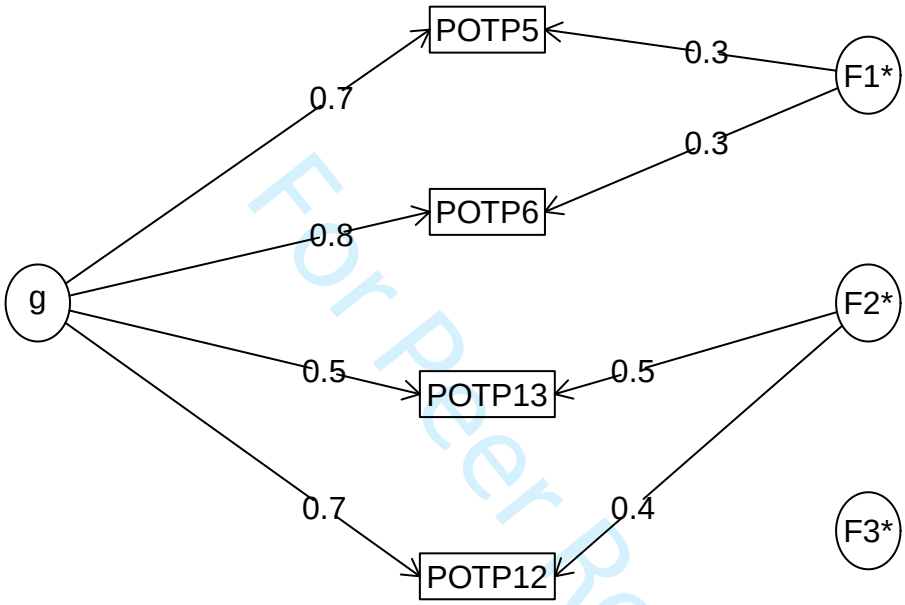
```r
## Add the new factor score to the dataset
covid19otlc.tpe$POPCLA <- lavPredict(pop.cfa3m.fit)[,c("POPCLA")]
covid19otlc.tpe$POPFED <- lavPredict(pop.cfa3m.fit)[,c("POPFED")]
covid19otlc.tpe$POPGEN <- lavPredict(pop.cfa3m.fit)[,c("POPGEN")]

############################################################
## Reliability coefficients (subscales)
omega(covid19otlc.tpe[, c("POTP1", "POTP2",
                          "POTP3", "POTP4")])
```




```
## Omega
## Call: omegah(m = m, nfactors = nfactors, fm = fm, key = key, flip = flip,
##     digits = digits, title = title, sl = sl, labels = labels,
##     plot = plot, n.obs = n.obs, rotate = rotate, Phi = Phi, option = option,
##     covar = covar)
## Alpha:                 0.9
## G.6:                   0.88
## Omega Hierarchical:    0.86
## Omega H asymptotic:    0.94
## Omega Total            0.92
##
## Schmid Leiman Factor loadings greater than  0.2
##          g  F1*  F2*  F3*   h2   u2   p2
```

```
## POTP1 0.82 0.41           0.84 0.16 0.79
## POTP2 0.79 0.42           0.82 0.18 0.77
## POTP3 0.82                0.69 0.31 0.97
## POTP4 0.83                0.69 0.31 0.99
##
## With eigenvalues of:
##    g  F1*  F2*  F3*
## 2.65 0.35 0.00 0.04
##
## general/max  7.68   max/min =   81.8
## mean percent general =  0.88    with sd =  0.12 and cv of  0.13
## Explained Common Variance of the general factor =  0.87
##
## The degrees of freedom are -3  and the fit is  0
## The number of observations was  222  with Chi Square =  0  with prob <  NA
## The root mean square of the residuals is  0
## The df corrected root mean square of the residuals is  NA
##
## Compare this with the adequacy of just a general factor and no group factors
## The degrees of freedom for just the general factor are 2  and the fit is  0.19
## The number of observations was  222  with Chi Square =  41.74  with prob <  8.6e-10
## The root mean square of the residuals is  0.07
## The df corrected root mean square of the residuals is  0.12
##
## RMSEA index =  0.299  and the 10 % confidence intervals are  0.225 0.382
## BIC =  30.93
##
## Measures of factor score adequacy
##                                                 g   F1*   F2*   F3*
## Correlation of scores with factors            0.93  0.67  0.08  0.41
## Multiple R square of scores with factors      0.87  0.45  0.01  0.17
## Minimum correlation of factor score estimates 0.74 -0.09 -0.99 -0.67
##
##  Total, General and Subset omega for each subset
##                                                    g  F1* F2*  F3*
## Omega total for total scores and subscales    0.92 0.91   NA 0.81
## Omega general for total scores and subscales  0.86 0.72   NA 0.81
## Omega group for total scores and subscales    0.06 0.19   NA 0.00
```

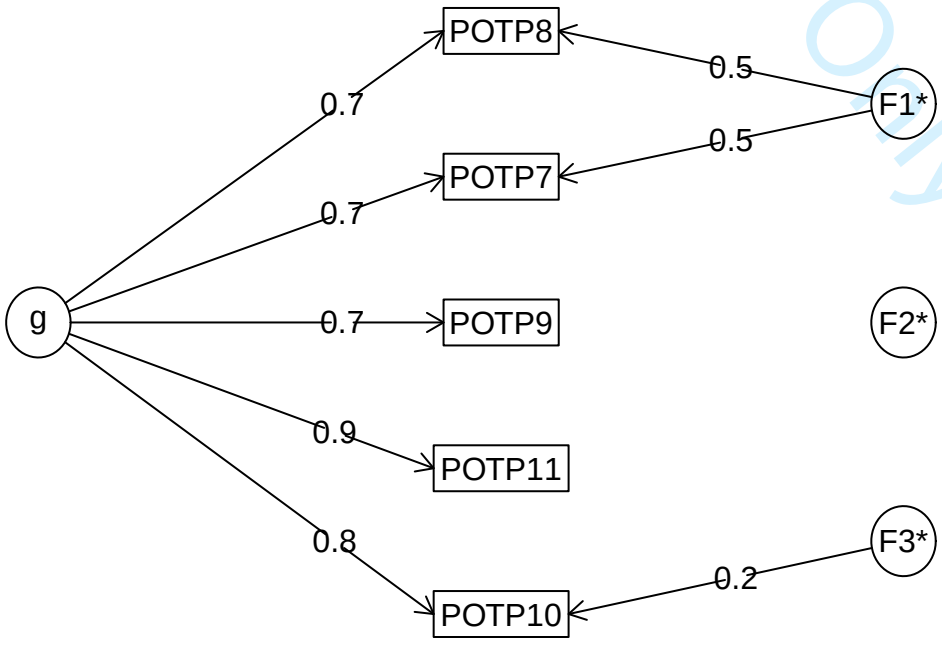
```
omega(covid19otlc.tpe[, c("POTP12", "POTP13",
                          "POTP5", "POTP6")])
```




```
## Omega
## Call: omegah(m = m, nfactors = nfactors, fm = fm, key = key, flip = flip,
##     digits = digits, title = title, sl = sl, labels = labels,
##     plot = plot, n.obs = n.obs, rotate = rotate, Phi = Phi, option = option,
##     covar = covar)
## Alpha:                 0.82
## G.6:                   0.8
## Omega Hierarchical:    0.74
## Omega H asymptotic:    0.86
## Omega Total            0.87
##
## Schmid Leiman Factor loadings greater than  0.2
##           g   F1*   F2*   F3*   h2   u2   p2
## POTP12 0.70        0.43       0.67 0.33 0.73
## POTP13 0.54        0.48       0.52 0.48 0.56
## POTP5  0.74  0.34             0.66 0.34 0.82
## POTP6  0.81  0.30             0.74 0.26 0.88
##
## With eigenvalues of:
##    g  F1*  F2*  F3*
## 1.97 0.21 0.41 0.00
##
## general/max  4.79   max/min =   193.6
## mean percent general =  0.75    with sd =  0.14 and cv of  0.19
## Explained Common Variance of the general factor =  0.76
##
## The degrees of freedom are -3  and the fit is  0
```

```
## The number of observations was  222  with Chi Square =  0  with prob <  NA
## The root mean square of the residuals is  0
## The df corrected root mean square of the residuals is  NA
##
## Compare this with the adequacy of just a general factor and no group factors
## The degrees of freedom for just the general factor are 2  and the fit is  0.15
## The number of observations was  222  with Chi Square =  32.7  with prob <  7.9e-08
## The root mean square of the residuals is  0.09
## The df corrected root mean square of the residuals is  0.16
##
## RMSEA index =  0.263  and the 10 % confidence intervals are  0.189 0.347
## BIC =  21.9
##
## Measures of factor score adequacy
##                                                 g   F1*   F2*   F3*
## Correlation of scores with factors            0.88  0.43  0.62  0.07
## Multiple R square of scores with factors      0.77  0.18  0.39  0.01
## Minimum correlation of factor score estimates 0.54 -0.64 -0.22 -0.99
##
##  Total, General and Subset omega for each subset
##                                                 g  F1*  F2* F3*
## Omega total for total scores and subscales    0.87 0.83 0.74  NA
## Omega general for total scores and subscales  0.74 0.70 0.48  NA
## Omega group for total scores and subscales    0.12 0.12 0.26  NA
```

```
omega(covid19otlc.tpe[, c("POTP7", "POTP8",
                          "POTP9", "POTP10",
                          "POTP11")])
```



```
## Omega
## Call: omegah(m = m, nfactors = nfactors, fm = fm, key = key, flip = flip,
##     digits = digits, title = title, sl = sl, labels = labels,
##     plot = plot, n.obs = n.obs, rotate = rotate, Phi = Phi, option = option,
##     covar = covar)
## Alpha:                 0.9
## G.6:                   0.89
## Omega Hierarchical:    0.85
## Omega H asymptotic:    0.91
## Omega Total            0.93
##
## Schmid Leiman Factor loadings greater than  0.2
##           g   F1*  F2*   F3*   h2   u2   p2
## POTP7  0.74  0.50          0.82 0.18 0.67
## POTP8  0.71  0.51          0.80 0.20 0.64
## POTP9  0.75                0.59 0.41 0.95
## POTP10 0.78           0.24 0.67 0.33 0.90
## POTP11 0.90                0.81 0.19 1.00
##
## With eigenvalues of:
##    g  F1*  F2*  F3*
## 3.03 0.53 0.00 0.12
##
## general/max  5.69   max/min =   514.27
## mean percent general =  0.83    with sd =  0.17 and cv of  0.2
## Explained Common Variance of the general factor =  0.82
##
## The degrees of freedom are -2  and the fit is  0
## The number of observations was  222  with Chi Square =  0  with prob <  NA
## The root mean square of the residuals is  0
## The df corrected root mean square of the residuals is  NA
##
## Compare this with the adequacy of just a general factor and no group factors
## The degrees of freedom for just the general factor are 5  and the fit is  0.29
## The number of observations was  222  with Chi Square =  63.18  with prob <  2.7e-12
## The root mean square of the residuals is  0.08
## The df corrected root mean square of the residuals is  0.12
##
## RMSEA index =  0.229  and the 10 % confidence intervals are  0.181 0.282
## BIC =  36.17
##
## Measures of factor score adequacy
##                                                 g  F1*   F2*   F3*
## Correlation of scores with factors            0.94 0.78  0.03  0.57
## Multiple R square of scores with factors      0.89 0.61  0.00  0.33
## Minimum correlation of factor score estimates 0.79 0.21 -1.00 -0.34
##
##  Total, General and Subset omega for each subset
##                                                 g  F1* F2*  F3*
## Omega total for total scores and subscales    0.93 0.88  NA 0.84
## Omega general for total scores and subscales  0.85 0.69  NA 0.84
## Omega group for total scores and subscales    0.08 0.19  NA 0.01
```

##

Initial Latent Profile Analysis

These analyses are to identify a baseline model which forms the basis for all subsequent LPAs.

```
## Select the relevant variables
covid19otlc.tpe.lpa <- data.frame(covid19otlc.tpe$gTPACK,
                                  covid19otlc.tpe$gPIS,
                                  covid19otlc.tpe$PISCO1,
                                  covid19otlc.tpe$PISCO2,
                                  covid19otlc.tpe$POPGEN,
                                  covid19otlc.tpe$POPCLA,
                                  covid19otlc.tpe$POPFED)

colnames(covid19otlc.tpe.lpa) <- c("gTPACK", "gPIS",
                                   "PISCO1", "PISCO2",
                                   "POPGEN", "POPCLA",
                                   "POPFED")

## Check the data
head(covid19otlc.tpe.lpa, 5)
```

```
##       gTPACK       gPIS PISCO1 PISCO2      POPGEN      POPCLA     POPFED
## 1 -0.5516057 -1.5310263      0      1 -0.37726481 -0.40870916 -0.3781949
## 2  0.9724480 -1.3388278      0      1  0.44953973  0.04469573  0.1678385
## 3  0.3589668  0.3055426      2      2  0.48244946  0.06474838  0.2943419
## 4 -2.0989683  1.0020314      3      2 -1.00380215 -0.06414635 -0.2455269
## 5  0.4081004 -0.1668300      1      3  0.09800701  0.81852216  0.4895920
```

```
## Perform LPAs with different assumptions
covid19otlc.tpe.lpa %>%
  single_imputation() %>%
  scale() %>%
  estimate_profiles(1:6,
                    package = "MplusAutomation",
                    variances = c("varying"),
                    covariances = c("zero")) %>%
    compare_solutions(statistics = c("AIC", "BIC", "Entropy",
                                     "BLRT_p", "AWE",
                                     "CLC", "KIC"))
```

```
## Warning:
## One or more analyses resulted in warnings! Examine these analyses carefully: model_2_class_4, model_
```

```
## Warning:
## One or more analyses resulted in warnings! Examine these analyses carefully: model_2_class_4, model_
```

```
## Warning: The solution with the maximum number of classes under consideration was
## considered to be the best solution according to one or more fit indices. Examine
## your results with care and consider estimating more classes.
```

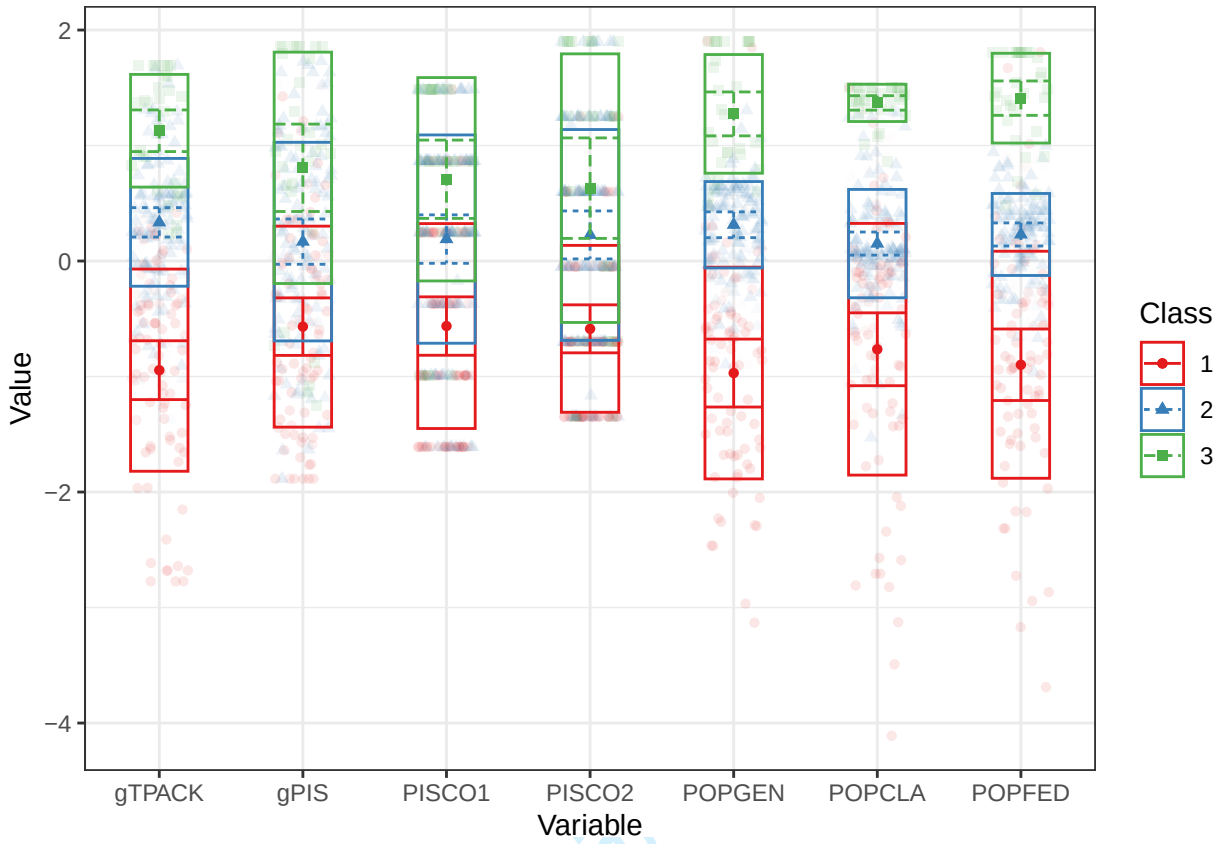
```
## Compare tidyLPA solutions:
##
##  Model Classes AIC      BIC      Entropy BLRT_p AWE      CLC      KIC
##  2     1       4431.046 4478.683 1.000           4594.321 4405.046 4448.046
##  2     2       3959.046 4057.724 0.857    0      4299.687 3902.760 3991.046
##  2     3       3676.034 3825.752 0.921    0      4193.628 3589.876 3723.034
```

```
##  2     4       3529.132 3729.890 0.919    0     4223.810 3412.970 3591.132
##  2     5       3399.824 3651.622 0.949    0     4271.522 3253.722 3476.824
##  2     6       3324.282 3627.120 0.938    0     4373.083 3148.158 3416.282
##  Warnings
##
##
##
##  Warning
##
##  Warning
##
## Best model according to AIC is Model 2 with 6 classes.
## Best model according to BIC is Model 2 with 6 classes.
## Best model according to Entropy is Model NA with NA classes.
## Best model according to BLRT_p is Model NA with NA classes.
## Best model according to AWE is Model 2 with 3 classes.
## Best model according to CLC is Model 2 with 6 classes.
## Best model according to KIC is Model 2 with 6 classes.
##
## An analytic hierarchy process, based on the fit indices AIC, AWE, BIC, CLC, and KIC (Akogul & Erisogl
```

```
## Final profile solution
lpa.final <- covid19otlc.tpe.lpa %>%
  single_imputation() %>%
  scale() %>%
  estimate_profiles(3,
                    package = "Mplus",
                    variances = c("varying"),
                    covariances = c("zero"))

## Extract the parameter estimates
get_estimates(lpa.final)
```

```
## # A tibble: 42 x 8
##    Category  Parameter Estimate    se     p Class Model Classes
##    <chr>     <chr>        <dbl> <dbl> <dbl> <int> <dbl>   <int>
##  1 Means     gTPACK      -0.945 0.13      0     1     2       3
##  2 Means     gPIS        -0.568 0.127     0     1     2       3
##  3 Means     PISCO1      -0.563 0.129     0     1     2       3
##  4 Means     PISCO2      -0.587 0.106     0     1     2       3
##  5 Means     POPGEN      -0.97  0.15      0     1     2       3
##  6 Means     POPCLA      -0.764 0.161     0     1     2       3
##  7 Means     POPFED      -0.898 0.158     0     1     2       3
##  8 Variances gTPACK       0.766 0.11      0     1     2       3
##  9 Variances gPIS         0.757 0.107     0     1     2       3
## 10 Variances PISCO1       0.787 0.088     0     1     2       3
## # ... with 32 more rows
```

```
## Plot the profiles
lpa.final %>%
  plot_profiles()
```



Correlation matrix including all variables submitted to LPA (Participant level)

Complete set of variables including profile indicators and covariates

```
############################################################
## Select the data
all.var <- c("gTPACK", "gPIS", "PISCO1", "PISCO2",
             "POPGEN", "POPCLA", "POPFED",
             "AGE", "FEMALE", "TEACHEXP",
             "OTLEXP", "OTLPREP", "OTLDAYS",
             "OTLSHIFT", "INSTDEC")
# Subset the data
final <- covid19otlc.tpe[all.var]
head(final, 5)
```

```
##       gTPACK       gPIS PISCO1 PISCO2      POPGEN      POPCLA     POPFED AGE
## 1 -0.5516057 -1.5310263      0      1 -0.37726481 -0.40870916 -0.3781949  40
## 2  0.9724480 -1.3388278      0      1  0.44953973  0.04469573  0.1678385  64
## 3  0.3589668  0.3055426      2      2  0.48244946  0.06474838  0.2943419  31
## 4 -2.0989683  1.0020314      3      2 -1.00380215 -0.06414635 -0.2455269  37
## 5  0.4081004 -0.1668300      1      3  0.09800701  0.81852216  0.4895920  37
##   FEMALE TEACHEXP OTLEXP OTLPREP OTLDAYS OTLSHIFT INSTDEC
## 1      0        5      0       0       1        2       2
## 2      1       23      1       0       1        2       2
## 3      1        7      0       0       1        2       1
## 4      1        7      0       0       0        2       2
## 5      1        7      0       2       1        2       2
```

```
############################################################
## Correlation matrix
## APA format
apa.cor.table(final, filename="Table_FINAL.doc", table.number=5)
```

```
##
##
## Table 5
##
## Means, standard deviations, and correlations with confidence intervals
##
##
##   Variable     M     SD    1           2           3           4
##   1. gTPACK    0.00  0.80
##
##   2. gPIS      -0.00 1.18  .36**
##                            [.24, .47]
##
##   3. PISCO1    2.60  1.62  .34**       .71**
##                            [.22, .45]  [.64, .77]
##
##   4. PISCO2    2.08  1.54  .37**       .72**       .68**
##                            [.25, .48]  [.65, .78]  [.60, .74]
##
```

```
##   5. POPGEN    -0.00 0.75  .66**       .35**       .32**       .33**
##                            [.58, .73]  [.23, .46]  [.19, .43]  [.21, .45]
##
##   6. POPCLA    0.00  0.65  .62**       .36**       .34**       .28**
##                            [.53, .69]  [.24, .47]  [.22, .45]  [.15, .39]
##
##   7. POPFED    -0.00 0.68  .65**       .36**       .33**       .33**
##                            [.56, .72]  [.24, .47]  [.21, .44]  [.21, .44]
##
##   8. AGE       43.46 10.65 -.01        -.07        -.08        -.10
##                            [-.15, .12] [-.20, .06] [-.21, .05] [-.23, .04]
##
##   9. FEMALE    0.69  0.46  -.11        .05         -.01        -.01
##                            [-.24, .02] [-.08, .18] [-.14, .12] [-.14, .12]
##
##   10. TEACHEXP 15.27 10.11 .02         -.02        .01         -.01
##                            [-.12, .15] [-.15, .11] [-.12, .14] [-.14, .13]
##
##   11. OTLEXP   0.26  0.44  .29**       .01         .04         .07
##                            [.16, .40]  [-.12, .15] [-.10, .17] [-.06, .20]
##
##   12. OTLPREP  4.29  11.12 .10         .15*        .12         .17*
##                            [-.03, .23] [.02, .28]  [-.02, .25] [.03, .30]
##
##   13. OTLDAYS  1.63  1.24  .14*        .03         .03         .07
##                            [.01, .27]  [-.10, .17] [-.11, .16] [-.06, .21]
##
##   14. OTLSHIFT 1.63  0.57  .09         -.02        .07         -.09
##                            [-.04, .22] [-.15, .11] [-.06, .20] [-.22, .05]
##
##   15. INSTDEC  1.61  0.63  .08         .10         .04         .03
##                            [-.05, .22] [-.03, .23] [-.09, .18] [-.11, .16]
##
##   5           6           7           8           9           10
##
##
##
##
##
##
##
##
##
##
##
##
##
##
##
##   .74**
##   [.68, .80]
##
##   .91**       .82**
##   [.88, .93]  [.78, .86]
##
```

```
##   .03          -.12         -.04
##   [-.10, .16] [-.24, .02] [-.17, .09]
##
##   .02          .05          .11          -.11
##   [-.11, .15] [-.08, .18] [-.02, .24] [-.24, .03]
##
##   .02          -.09         -.01         .73**        .02
##   [-.11, .16] [-.22, .04] [-.14, .12] [.66, .79]   [-.11, .15]
##
##   .19**        .15*         .12          .03          -.21**        .08
##   [.06, .32]   [.02, .28]   [-.01, .25] [-.10, .16] [-.34, -.08] [-.05, .21]
##
##   .07          .09          .06          .01          -.15*         .03
##   [-.07, .20] [-.05, .22] [-.07, .20] [-.13, .15] [-.28, -.01] [-.10, .17]
##
##   .09          .00          .05          -.00         .06           .06
##   [-.05, .22] [-.13, .14] [-.09, .18] [-.14, .13] [-.07, .19]   [-.08, .19]
##
##   .01          .15*         .09          .02          .03           .05
##   [-.12, .14] [.02, .28]   [-.04, .22] [-.11, .15] [-.10, .16]   [-.08, .18]
##
##   .04          .09          .11          .04          .21**         .01
##   [-.10, .17] [-.05, .22] [-.02, .24] [-.09, .18] [.08, .33]    [-.12, .15]
##
##   11           12           13           14
```

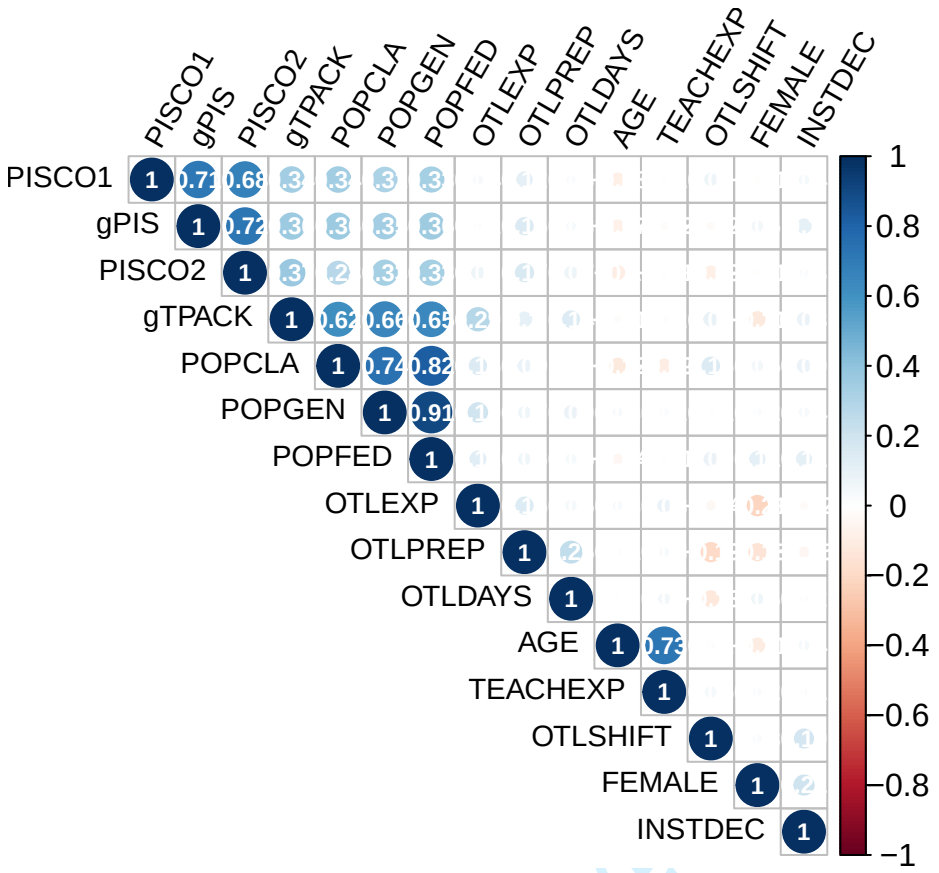
```
##
##
##
##   .15*
##   [.01, .28]
##
##   .05         .25**
##   [-.09, .18] [.12, .37]
##
##   -.04        -.19**       -.13
##   [-.17, .10] [-.32, -.06] [-.26, .01]
##
##   -.02        -.05         .02         .19**
##   [-.16, .11] [-.18, .09]  [-.12, .15] [.05, .31]
##
##
## Note. M and SD are used to represent mean and standard deviation, respectively.
## Values in square brackets indicate the 95% confidence interval.
## The confidence interval is a plausible range of population correlations
## that could have caused the sample correlation (Cumming, 2014).
## * indicates p < .05. ** indicates p < .01.
##
```

```
## Extract the Pearson correlation matrix
final.cor <- cor(final, method = "pearson",
                 use = "pairwise.complete.obs")
final.cor
```

```
##               gTPACK        gPIS       PISCO1       PISCO2      POPGEN
## gTPACK    1.00000000  0.36378376  0.342599667  0.373471844 0.657551951
## gPIS      0.36378376  1.00000000  0.713564097  0.723394309 0.346819967
## PISCO1    0.34259967  0.71356410  1.000000000  0.678503848 0.318422560
## PISCO2    0.37347184  0.72339431  0.678503848  1.000000000 0.333110206
## POPGEN    0.65755195  0.34681997  0.318422560  0.333110206 1.000000000
## POPCLA    0.61935365  0.36031817  0.342974996  0.275622496 0.743304080
## POPFED    0.64509609  0.35978583  0.332187312  0.331718273 0.907107761
## AGE      -0.01397439 -0.07022982 -0.083566288 -0.095108474 0.031235062
## FEMALE   -0.11448192  0.05152851 -0.009629224 -0.009066709 0.021010420
## TEACHEXP  0.01505928 -0.01804544  0.008443395 -0.007285794 0.024202183
## OTLEXP    0.28523085  0.01409912  0.036466801  0.071658274 0.194533036
## OTLPREP   0.10255272  0.15228867  0.116061334  0.167847174 0.068322620
## OTLDAYS   0.14459727  0.03320870  0.028603255  0.074731418 0.086197301
## OTLSHIFT  0.09448201 -0.02005882  0.070607647 -0.086651632 0.007595381
## INSTDEC   0.08366321  0.10225464  0.042048702  0.027601752 0.038758841
##                POPCLA       POPFED          AGE       FEMALE     TEACHEXP
## gTPACK    0.619353648  0.645096087 -0.013974389 -0.114481917  0.015059277
## gPIS      0.360318173  0.359785831 -0.070229824  0.051528509 -0.018045443
## PISCO1    0.342974996  0.332187312 -0.083566288 -0.009629224  0.008443395
## PISCO2    0.275622496  0.331718273 -0.095108474 -0.009066709 -0.007285794
## POPGEN    0.743304080  0.907107761  0.031235062  0.021010420  0.024202183
## POPCLA    1.000000000  0.823311673 -0.116027081  0.050320030 -0.090952768
## POPFED    0.823311673  1.000000000 -0.042948382  0.113935021 -0.008990708
## AGE      -0.116027081 -0.042948382  1.000000000 -0.107016958  0.728463774
## FEMALE    0.050320030  0.113935021 -0.107016958  1.000000000  0.021706925
## TEACHEXP -0.090952768 -0.008990708  0.728463774  0.021706925  1.000000000
```

```
## OTLEXP    0.150956935  0.124640703  0.030373818 -0.213627397  0.080517596
## OTLPREP   0.085158187  0.063777109  0.010993065 -0.149837931  0.032852959
## OTLDAYS   0.001710276  0.045011585 -0.003229284  0.061152369  0.056407702
## OTLSHIFT  0.153779937  0.088270726  0.018498793  0.029401356  0.049744250
## INSTDEC   0.089537145  0.113681906  0.041903106  0.209552786  0.012983900
##               OTLEXP     OTLPREP      OTLDAYS     OTLSHIFT     INSTDEC
## gTPACK    0.28523085  0.10255272  0.144597274  0.094482015  0.08366321
## gPIS      0.01409912  0.15228867  0.033208701 -0.020058820  0.10225464
## PISCO1    0.03646680  0.11606133  0.028603255  0.070607647  0.04204870
## PISCO2    0.07165827  0.16784717  0.074731418 -0.086651632  0.02760175
## POPGEN    0.19453304  0.06832262  0.086197301  0.007595381  0.03875884
## POPCLA    0.15095694  0.08515819  0.001710276  0.153779937  0.08953714
## POPFED    0.12464070  0.06377711  0.045011585  0.088270726  0.11368191
## AGE       0.03037382  0.01099307 -0.003229284  0.018498793  0.04190311
## FEMALE   -0.21362740 -0.14983793  0.061152369  0.029401356  0.20955279
## TEACHEXP  0.08051760  0.03285296  0.056407702  0.049744250  0.01298390
## OTLEXP    1.00000000  0.14969646  0.047868357 -0.035304724 -0.02252669
## OTLPREP   0.14969646  1.00000000  0.248670442 -0.191591921 -0.04946236
## OTLDAYS   0.04786836  0.24867044  1.000000000 -0.126775001  0.01865658
## OTLSHIFT -0.03530472 -0.19159192 -0.126775001  1.000000000  0.18682486
## INSTDEC  -0.02252669 -0.04946236  0.018656584  0.186824865  1.00000000
```

```
## Correlogram
corrplot(final.cor, type = "upper", order = "hclust",
         tl.col = "black", tl.srt = 60,
         addCoef.col = "white",
         number.cex = 0.75,
         cl.cex = 1,
         tl.cex = 0.9)
```




```
#############################################################
```

Profile indicators

```
#############################################################
## Select the data
pro.var <- c("gTPACK", "gPIS", "PISCO1", "PISCO2",
             "POPGEN", "POPCLA", "POPFED")
# Subset the data
final.pro <- covid19otlc.tpe[pro.var]
head(final.pro, 5)
```

```
##       gTPACK       gPIS PISCO1 PISCO2      POPGEN      POPCLA      POPFED
## 1 -0.5516057 -1.5310263      0      1 -0.37726481 -0.40870916 -0.3781949
## 2  0.9724480 -1.3388278      0      1  0.44953973  0.04469573  0.1678385
## 3  0.3589668  0.3055426      2      2  0.48244946  0.06474838  0.2943419
## 4 -2.0989683  1.0020314      3      2 -1.00380215 -0.06414635 -0.2455269
## 5  0.4081004 -0.1668300      1      3  0.09800701  0.81852216  0.4895920
```

```
#############################################################
## Correlation matrix
## APA format
apa.cor.table(final.pro, filename="Table_PROFILE.doc", table.number=6)
```

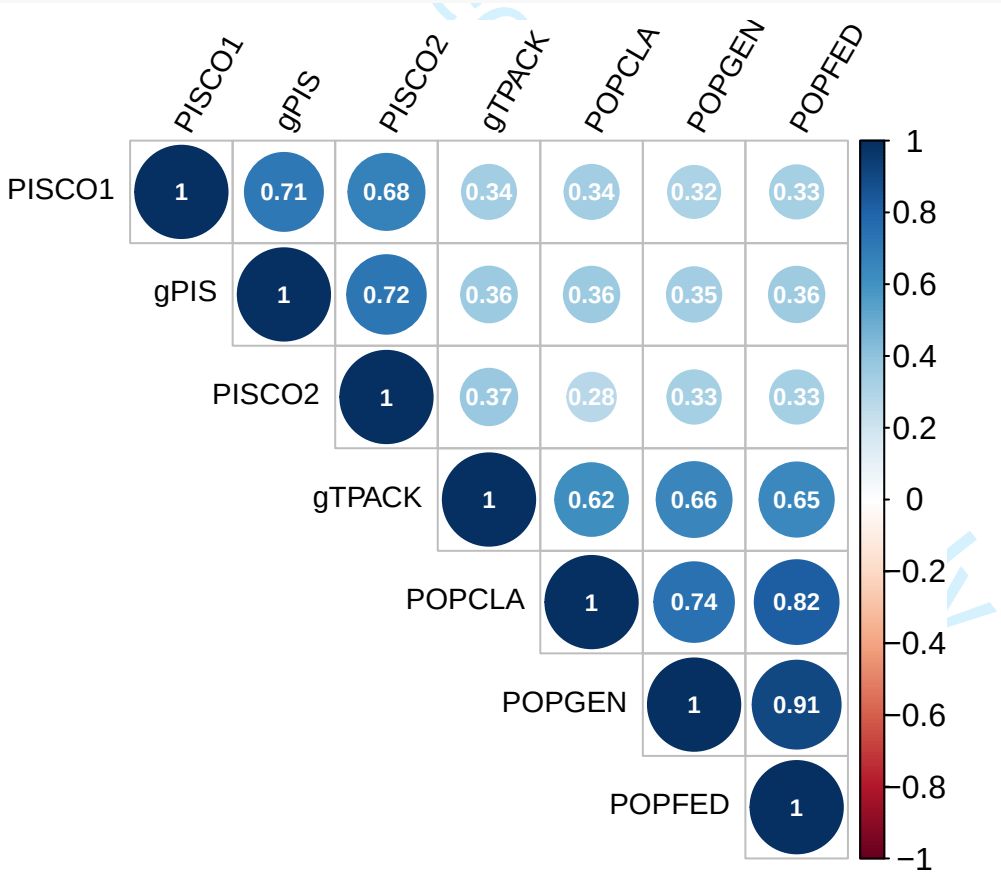
```
##
##
```

```
## Table 6
##
## Means, standard deviations, and correlations with confidence intervals
##
##
##   Variable  M     SD   1          2          3          4          5
##   1. gTPACK 0.00  0.80
##
##   2. gPIS   -0.00 1.18 .36**
##                        [.24, .47]
##
##   3. PISCO1 2.60  1.62 .34**      .71**
##                        [.22, .45] [.64, .77]
##
##   4. PISCO2 2.08  1.54 .37**      .72**      .68**
##                        [.25, .48] [.65, .78] [.60, .74]
##
##   5. POPGEN -0.00 0.75 .66**      .35**      .32**      .33**
##                        [.58, .73] [.23, .46] [.19, .43] [.21, .45]
##
##   6. POPCLA 0.00  0.65 .62**      .36**      .34**      .28**      .74**
##                        [.53, .69] [.24, .47] [.22, .45] [.15, .39] [.68, .80]
##
##   7. POPFED -0.00 0.68 .65**      .36**      .33**      .33**      .91**
##                        [.56, .72] [.24, .47] [.21, .44] [.21, .44] [.88, .93]
##
##   6
##
##
##
##
##
##
##
##
##
##
##
##
##
##
##
##
##
##
##
##   .82**
##   [.78, .86]
##
##
## Note. M and SD are used to represent mean and standard deviation, respectively.
## Values in square brackets indicate the 95% confidence interval.
## The confidence interval is a plausible range of population correlations
## that could have caused the sample correlation (Cumming, 2014).
## * indicates p < .05. ** indicates p < .01.
##
```

```r
## Extract the Pearson correlation matrix
final.pro.cor <- cor(final.pro, method = "pearson",
                     use = "pairwise.complete.obs")
final.pro.cor
```

```
##            gTPACK      gPIS    PISCO1    PISCO2    POPGEN    POPCLA    POPFED
## gTPACK 1.0000000 0.3637838 0.3425997 0.3734718 0.6575520 0.6193536 0.6450961
## gPIS   0.3637838 1.0000000 0.7135641 0.7233943 0.3468200 0.3603182 0.3597858
## PISCO1 0.3425997 0.7135641 1.0000000 0.6785038 0.3184226 0.3429750 0.3321873
## PISCO2 0.3734718 0.7233943 0.6785038 1.0000000 0.3331102 0.2756225 0.3317183
## POPGEN 0.6575520 0.3468200 0.3184226 0.3331102 1.0000000 0.7433041 0.9071078
## POPCLA 0.6193536 0.3603182 0.3429750 0.2756225 0.7433041 1.0000000 0.8233117
## POPFED 0.6450961 0.3597858 0.3321873 0.3317183 0.9071078 0.8233117 1.0000000
```

```r
## Correlogram
corrplot(final.pro.cor, type = "upper", order = "hclust",
         tl.col = "black", tl.srt = 60,
         addCoef.col = "white",
         number.cex = 0.75,
         cl.cex = 1,
         tl.cex = 0.9)
```




```r
############################################################
```

Extract the data for Mplus

```
## Save the data file
# csv-file
write.csv2(covid19otlc.tpe, file = "COVID19OTLC-TPE-LPA.csv",
           row.names = FALSE)

# dat-file
write.table(covid19otlc.tpe, file = "COVID19OTLC-TPE-LPA.dat",
            sep = "\t", dec = ".", na = "-999",
            col.names = FALSE, row.names = FALSE)

# Variable (column) names
colnames(covid19otlc.tpe)
```

```
##  [1] "COUNTRYID"  "COHORTID"   "PERSONID"   "UNPERSID"   "REGIONID"
##  [6] "EDUCATION"  "AGE"        "FEMALE"     "TEACHEXP"   "SUBJECT"
## [11] "ONTEACHEXP" "OTLEXP"     "ONTEACHPER" "OTLPREP"    "OPLAT"
## [16] "OTLSHIFT"   "OTLDAYS"    "INSTDEC"    "TCK1"       "TCK2"
## [21] "TPK1"       "TPK2"       "TPK3"       "TPK4"       "TPCK1"
## [26] "TPCK2"      "TPCK3"      "TPCK4"      "POTP1"      "POTP2"
## [31] "POTP3"      "POTP4"      "POTP5"      "POTP6"      "POTP7"
## [36] "POTP8"      "POTP9"      "POTP10"     "POTP11"     "POTP12"
## [41] "POTP13"     "PIS1"       "PIS2"       "PIS3"       "PIS4"
## [46] "PIS5"       "PIS6"       "PISCO1"     "PISCO2"     "GII"
## [51] "GII21"      "GII22"      "GII23"      "GII31"      "GII73"
## [56] "SELF"       "TEAM"       "PORGIN"     "STRATIO"    "PREPICT"
## [61] "PRACICT"    "PDICT"      "COOP"       "WELS"       "PDI"
## [66] "IDV"        "MAS"        "UAI"        "LTO"        "IVR"
## [71] "EUROPE"     "gTPACK"     "gPIS"       "POPCLA"     "POPFED"
## [76] "POPGEN"
```

R session info

```
sessionInfo()
```

```
## R version 4.0.2 (2020-06-22)
## Platform: x86_64-apple-darwin17.0 (64-bit)
## Running under: macOS Catalina 10.15.5
##
## Matrix products: default
## BLAS:   /Library/Frameworks/R.framework/Versions/4.0/Resources/lib/libRblas.dylib
## LAPACK: /Library/Frameworks/R.framework/Versions/4.0/Resources/lib/libRlapack.dylib
##
## locale:
## [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
##  [1] dplyr_1.0.0             tidyLPA_1.0.7
##  [3] polycor_0.7-10          PerformanceAnalytics_2.0.4
##  [5] xts_0.12-0              zoo_1.8-8
##  [7] apaTables_2.0.5         ggrepel_0.8.2
##  [9] ggpubr_0.4.0            ggplot2_3.3.2
## [11] corrplot_0.84           semPlot_1.1.2
## [13] psych_1.9.12.31         lavaan_0.6-6
##
## loaded via a namespace (and not attached):
##   [1] readxl_1.3.1          backports_1.1.8       Hmisc_4.4-0
##   [4] BDgraph_2.62          plyr_1.8.6            igraph_1.2.5
##   [7] GPArotation_2014.11-1 splines_4.0.2         MplusAutomation_0.7-3
##  [10] digest_0.6.25         htmltools_0.5.0       matrixcalc_1.0-3
##  [13] fansi_0.4.1           magrittr_1.5          Rsolnp_1.16
##  [16] checkmate_2.0.0       lisrelToR_0.1.4       cluster_2.1.0
##  [19] openxlsx_4.1.5        jpeg_0.1-8.1          sem_3.1-11
##  [22] colorspace_1.4-1      haven_2.3.1           xfun_0.15
##  [25] crayon_1.3.4          lme4_1.1-23           regsem_1.5.2
##  [28] survival_3.1-12       glue_1.4.1            gtable_0.3.0
##  [31] mi_1.0                car_3.0-8             abind_1.4-5
##  [34] scales_1.1.1          rstatix_0.6.0         Rcpp_1.0.4.6
##  [37] xtable_1.8-4          htmlTable_2.0.0       tmvnsim_1.0-2
##  [40] mclust_5.4.6          foreign_0.8-80        Formula_1.2-3
##  [43] stats4_4.0.2          truncnorm_1.0-8       htmlwidgets_1.5.1
##  [46] httr_1.4.1            RColorBrewer_1.1-2    acepack_1.4.1
##  [49] ellipsis_0.3.1        farver_2.0.3          pkgconfig_2.0.3
##  [52] XML_3.99-0.3          nnet_7.3-14           kutils_1.70
##  [55] utf8_1.1.4            labeling_0.3          tidyselect_1.1.0
##  [58] rlang_0.4.6           reshape2_1.4.4        munsell_0.5.0
##  [61] cellranger_1.1.0      tools_4.0.2           cli_2.0.2
##  [64] gsubfn_0.7            generics_0.0.2        broom_0.5.6
##  [67] fdrtool_1.2.15        evaluate_0.14         stringr_1.4.0
##  [70] arm_1.11-1            yaml_2.2.1            knitr_1.29
##  [73] zip_2.0.4             pander_0.6.3          purrr_0.3.4
```

```
##  [76] glasso_1.11          pbapply_1.4-2        nlme_3.1-148
##  [79] whisker_0.4          compiler_4.0.2       rstudioapi_0.11
##  [82] curl_4.3             png_0.1-7            ggsignif_0.6.0
##  [85] mix_1.0-10           huge_1.3.4.1         tibble_3.0.1
##  [88] statmod_1.4.34       pbivnorm_0.6.0       stringi_1.4.6
##  [91] qgraph_1.6.5         rockchalk_1.8.144    forcats_0.5.0
##  [94] lattice_0.20-41      texreg_1.37.4        Matrix_1.2-18
##  [97] nloptr_1.2.2.1       vctrs_0.3.1          pillar_1.4.4
## [100] lifecycle_0.2.0      OpenMx_2.17.4        data.table_1.12.8
## [103] corpcor_1.6.9        R6_2.4.1             latticeExtra_0.6-29
## [106] gridExtra_2.3        rio_0.5.16           codetools_0.2-16
## [109] assertthat_0.2.1     boot_1.3-25          MASS_7.3-51.6
## [112] gtools_3.8.2         proto_1.0.0          rjson_0.2.20
## [115] withr_2.2.0          mnormt_2.0.0         parallel_4.0.2
## [118] hms_0.5.3            quadprog_1.5-8       grid_4.0.2
## [121] rpart_4.1-15         tidyr_1.1.0          coda_0.19-3
## [124] minqa_1.2.4          rmarkdown_2.3        carData_3.0-4
## [127] d3Network_0.5.2.1    base64enc_0.1-3
```

Supplementary Material S2

Ready, set, go! Profiling readiness for online teaching

Contents

M*plus* sample code of the Latent Profile Analysis (LPA) with four profiles

```
TITLE:    COVID-19 Readiness Survey
          Latent profile analysis

DATA:     FILE IS COVID19OTLC-TPE-LPA.dat;
          FORMAT IS FREE;

VARIABLE:
     NAMES ARE
          COUNTRYID COHORTID PERSONID UNPERSID REGIONID
          EDUCATION AGE FEMALE TEACHEXP SUBJECT
          ONTEACHEXP OTLEXP ONTEACHPER OTLPREP OPLAT
          OTLSHIFT OTLDAYS INSTDEC
          TCK1 TCK2
          TPK1 TPK2 TPK3 TPK4
          TPCK1 TPCK2 TPCK3 TPCK4
          POTP1-POTP13
          PIS1-PIS6 PISCO1 PISCO2
          GII GII21 GII22 GII23 GII31 GII73
          SELF TEAM PORGIN STRATIO PREPICT
          PRACICT PDICT COOP WELS
          PDI IDV MAS UAI LTO IVR
          gTPACK gPIS POPCLA POPFED POPGEN;

     MISSING ARE ALL(-999);
     ! Indicate how missing values are coded

     IDVARIABLE = UNPERSID;
     ! Teacher ID to appear in the output files

     CLUSTER = COUNTRYID;
     ! Clustering of teacher data in countries

     USEVARIABLES ARE
     gTPACK gPIS PISCO1 PISCO2 POPCLA POPFED POPGEN;
     ! Specify the profile indicators

     CLASSES = c(4);
     ! Number of classes to be extracted

DEFINE:
     CENTER PISCO1 PISCO2(grandmean);
     ! Grandmean-centering of selected variables


ANALYSIS:
     TYPE = MIXTURE COMPLEX;
     ESTIMATOR = MLR;
     PROCESSORS = 8(STARTS);
     H1ITERATIONS = 100000;
```

```
      STARTS = 2000 100;


MODEL:
      %OVERALL%

      %c#1%
      ! Means freely estimated
      [gTPACK-POPGEN];

      ! Allow for variances
      gTPACK-POPGEN;


      %c#2%
      ! Means freely estimated
      [gTPACK-POPGEN];

      ! Allow for variances
      gTPACK-POPGEN;

      %c#3%
      ! Means freely estimated
      [gTPACK-POPGEN];

      ! Allow for variances
      gTPACK-POPGEN;

      %c#4%
      ! Means freely estimated
      [gTPACK-POPGEN];

      ! Allow for variances
      gTPACK-POPGEN;


OUTPUT:
      STDYX;
      CINTERVAL;
      TECH1;
      TECH7;
      TECH11;
      TECH14;
      SVALUES;

SAVEDATA:
  file is LPA4v-CPROB.dat ;
  save is cprob;
  format is free;
```

Mplus sample code of the Latent Profile Analysis (LPA) with four profiles and covariates using the direct-inclusion approach

```
TITLE:    COVID-19 Readiness Survey
          Latent profile analysis with covariates
          Direct inclusion approach

DATA:     FILE IS COVID19OTLC-TPE-LPA.dat;
          FORMAT IS FREE;

VARIABLE:
     NAMES ARE
          COUNTRYID COHORTID PERSONID UNPERSID REGIONID
          EDUCATION AGE FEMALE TEACHEXP SUBJECT
          ONTEACHEXP OTLEXP ONTEACHPER OTLPREP OPLAT
          OTLSHIFT OTLDAYS INSTDEC
          TCK1 TCK2
          TPK1 TPK2 TPK3 TPK4
          TPCK1 TPCK2 TPCK3 TPCK4
          POTP1-POTP13
          PIS1-PIS6 PISCO1 PISCO2
          GII GII21 GII22 GII23 GII31 GII73
          SELF TEAM PORGIN STRATIO PREPICT
          PRACICT PDICT COOP WELS
          PDI IDV MAS UAI LTO IVR
          gTPACK gPIS POPCLA POPFED POPGEN;

     MISSING ARE ALL(-999);
     ! Indicate how missing values are coded

     IDVARIABLE = UNPERSID;
     ! Teacher ID to appear in the output files

     CLUSTER = COUNTRYID;
     ! Clustering of teacher data in countries

     USEVARIABLES ARE
     gTPACK gPIS PISCO1 PISCO2 POPCLA POPFED POPGEN
     AGE FEMALE TEACHEXP
     OTLEXP OTLPREP OTLDAYS OTLSHIFT INSTDEC;
     ! Specify the profile indicators and covariates

     CLASSES = c(4);
     ! Number of classes to be extracted

DEFINE:
     CENTER PISCO1 PISCO2(grandmean);
     ! Grandmean-centering of selected variables
```

```
ANALYSIS:
     TYPE = MIXTURE COMPLEX;
     ESTIMATOR = MLR;
     PROCESSORS = 8(STARTS);
     H1ITERATIONS = 100000;
     STARTS = 2000 100;


MODEL:
     %OVERALL%
     ! Regression model
     c#1-c#3 ON
          AGE
          FEMALE
          TEACHEXP
          OTLEXP
          OTLPREP
          OTLDAYS
          OTLSHIFT
          INSTDEC;

     %c#1%
     ! Means freely estimated
     [gTPACK-POPGEN];

     ! Allow for variances
     gTPACK-POPGEN;


     %c#2%
     ! Means freely estimated
     [gTPACK-POPGEN];

     ! Allow for variances
     gTPACK-POPGEN;

     %c#3%
     ! Means freely estimated
     [gTPACK-POPGEN];

     ! Allow for variances
     gTPACK-POPGEN;

     %c#4%
     ! Means freely estimated
     [gTPACK-POPGEN];

     ! Allow for variances
     gTPACK-POPGEN;
```

```
OUTPUT:
      STDYX;
      CINTERVAL;
      TECH1;
      TECH7;
      TECH11;
      TECH14;
      SVALUES;
```

M*plus* sample code of the Latent Profile Analysis (LPA) with four profiles and covariates using the indirect auxiliary-variables approach (R3STEP)

```
TITLE:    COVID-19 Readiness Survey
          Latent profile analysis with covariates
          R3STEP approach

DATA:     FILE IS COVID19OTLC-TPE-LPA.dat;
          FORMAT IS FREE;

VARIABLE:
     NAMES ARE
          COUNTRYID COHORTID PERSONID UNPERSID REGIONID
          EDUCATION AGE FEMALE TEACHEXP SUBJECT
          ONTEACHEXP OTLEXP ONTEACHPER OTLPREP OPLAT
          OTLSHIFT OTLDAYS INSTDEC
          TCK1 TCK2
          TPK1 TPK2 TPK3 TPK4
          TPCK1 TPCK2 TPCK3 TPCK4
          POTP1-POTP13
          PIS1-PIS6 PISCO1 PISCO2
          GII GII21 GII22 GII23 GII31 GII73
          SELF TEAM PORGIN STRATIO PREPICT
          PRACICT PDICT COOP WELS
          PDI IDV MAS UAI LTO IVR
          gTPACK gPIS POPCLA POPFED POPGEN;

     MISSING ARE ALL(-999);
     ! Indicate how missing values are coded

     IDVARIABLE = UNPERSID;
     ! Teacher ID to appear in the output files

     CLUSTER = COUNTRYID;
     ! Clustering of teacher data in countries

     USEVARIABLES ARE
     gTPACK gPIS PISCO1 PISCO2 POPCLA POPFED POPGEN
     AGE FEMALE TEACHEXP
     OTLEXP OTLPREP OTLDAYS OTLSHIFT INSTDEC;
     ! Specify the profile indicators and covariates

     CLASSES = c(4);
     ! Number of classes to be extracted

     AUXILIARY ARE
          AGE(r3step)
          FEMALE(r3step)
          TEACHEXP(r3step)
          OTLEXP(r3step)
```

```
          OTLPREP(r3step)
          OTLDAYS(r3step)
          OTLSHIFT(r3step)
          INSTDEC(r3step);
     ! Specify the covariates as auxiliary variables


DEFINE:
     CENTER PISCO1 PISCO2(grandmean);
     ! Grandmean-centering of selected variables


ANALYSIS:
     TYPE = MIXTURE COMPLEX;
     ESTIMATOR = MLR;
     PROCESSORS = 8(STARTS);
     H1ITERATIONS = 100000;
     STARTS = 2000 100;


MODEL:
     %OVERALL%

     %c#1%
     ! Means freely estimated
     [gTPACK-POPGEN];

     ! Allow for variances
     gTPACK-POPGEN;


     %c#2%
     ! Means freely estimated
     [gTPACK-POPGEN];

     ! Allow for variances
     gTPACK-POPGEN;

     %c#3%
     ! Means freely estimated
     [gTPACK-POPGEN];

     ! Allow for variances
     gTPACK-POPGEN;

     %c#4%
     ! Means freely estimated
     [gTPACK-POPGEN];

     ! Allow for variances
     gTPACK-POPGEN;
```

```
OUTPUT:
      STDYX;
      CINTERVAL;
      TECH1;
      TECH7;
      TECH11;
      TECH14;
      SVALUES;
```

Results of the Latent Profile Analysis (LPA) with four profiles and covariates using the indirect-inclusion approach with covariates as auxiliary variables (R3STEP)

*Logistic regression: Probability of being assigned to **PROFILE 1 vs. PROFILE 4** as the outcome variable*

Variable	*B*	*SE*	*OR*	*p*
AGE	-0.028	0.014	0.972	0.038
FEMALE	0.146	0.297	1.157	0.623
TEACHEXP	0.036	0.022	1.036	0.102
OTLEXP	-2.399	0.420	0.091	0.000
OTLPREP	-0.070	0.072	0.932	0.331
OTLDAYS	-0.297	0.253	0.743	0.239
OTLSHIFT	-0.099	0.612	0.906	0.872
INSTDEC	-0.651	0.356	0.522	0.067

*Logistic regression: Probability of being assigned to **PROFILE 2 vs. PROFILE 4** as the outcome variable*

Variable	*B*	*SE*	*OR*	*p*
AGE	0.030	0.021	1.031	0.147
FEMALE	-1.069	0.278	0.343	0.000
TEACHEXP	-0.006	0.021	0.994	0.763
OTLEXP	-1.726	0.544	0.178	0.002
OTLPREP	-0.174	0.114	0.840	0.128
OTLDAYS	0.018	0.232	1.018	0.938
OTLSHIFT	-0.042	0.578	0.959	0.943
INSTDEC	-0.251	0.291	0.778	0.387

*Logistic regression: Probability of being assigned to **PROFILE 3 vs. PROFILE 4** as the outcome variable*

Variable	*B*	*SE*	*OR*	*p*
AGE	0.014	0.024	1.014	0.558
FEMALE	-0.689	0.569	0.502	0.226
TEACHEXP	0.005	0.024	1.005	0.835
OTLEXP	-0.996	0.294	0.369	0.001
OTLPREP	-0.046	0.023	0.955	0.040
OTLDAYS	0.256	0.122	1.292	0.035
OTLSHIFT	-0.475	0.505	0.622	0.347
INSTDEC	-0.021	0.264	0.979	0.936

*Logistic regression: Probability of being assigned to **PROFILE 3 vs. PROFILE 2** as the outcome variable*

Variable	*B*	*SE*	*OR*	*p*
AGE	-0.016	0.012	0.984	0.180
FEMALE	0.381	0.412	1.464	0.355
TEACHEXP	0.011	0.016	1.011	0.476
OTLEXP	0.730	0.392	2.075	0.062
OTLPREP	0.128	0.107	1.136	0.234
OTLDAYS	0.238	0.252	1.269	0.344
OTLSHIFT	-0.433	0.231	0.648	0.061
INSTDEC	0.230	0.299	1.259	0.442

*Logistic regression: Probability of being assigned to **PROFILE 1 vs. PROFILE** 2 as the outcome variable*

Variable	*B*	*SE*	*OR*	*p*
AGE	-0.059	0.017	0.943	0.001
FEMALE	1.216	0.324	3.372	0.000
TEACHEXP	0.042	0.014	1.043	0.003
OTLEXP	-0.674	0.382	0.510	0.078
OTLPREP	0.104	0.111	1.110	0.347
OTLDAYS	-0.316	0.149	0.729	0.035
OTLSHIFT	-0.057	0.441	0.945	0.897
INSTDEC	-0.399	0.193	0.671	0.039

*Logistic regression: Probability of being assigned to **PROFILE 1 vs. PROFILE 3** as the outcome variable*

Variable	*B*	*SE*	*OR*	*p*
AGE	-0.042	0.021	0.959	0.039
FEMALE	0.835	0.470	2.304	0.076
TEACHEXP	0.030	0.014	1.031	0.030
OTLEXP	-1.403	0.217	0.246	0.000
OTLPREP	-0.024	0.052	0.976	0.648
OTLDAYS	-0.554	0.285	0.575	0.052
OTLSHIFT	0.377	0.373	1.457	0.312
INSTDEC	-0.630	0.404	0.533	0.119

Results of the Latent Profile Analysis (LPA) with four profiles and covariates using the direct-inclusion approach

*Logistic regression: Probability of being assigned to **PROFILE 1 vs. PROFILE 4** as the outcome variable*

Variable	*B*	*SE*	*OR*	*p*
AGE	-0.030	0.013	0.971	0.020
FEMALE	0.088	0.297	1.092	0.767
TEACHEXP	0.030	0.022	1.030	0.164
OTLEXP	-2.518	0.520	0.081	0.000
OTLPREP	-0.092	0.076	0.912	0.221
OTLDAYS	-0.365	0.227	0.694	0.108
OTLSHIFT	-0.278	0.639	0.757	0.663
INSTDEC	-0.567	0.305	0.567	0.063

*Logistic regression: Probability of being assigned to **PROFILE 2 vs. PROFILE 4** as the outcome variable*

Variable	*B*	*SE*	*OR*	*p*
AGE	0.024	0.024	1.025	0.308
FEMALE	-1.045	0.318	0.352	0.001
TEACHEXP	-0.002	0.020	0.998	0.904
OTLEXP	-1.498	0.673	0.224	0.026
OTLPREP	-0.158	0.090	0.854	0.080
OTLDAYS	0.020	0.189	1.020	0.916
OTLSHIFT	0.011	0.624	1.011	0.986
INSTDEC	-0.243	0.311	0.784	0.435

*Logistic regression: Probability of being assigned to **PROFILE 3 vs. PROFILE 4** as the outcome variable*

Variable	*B*	*SE*	*OR*	*p*
AGE	0.016	0.022	1.016	0.465
FEMALE	-0.689	0.536	0.502	0.199
TEACHEXP	0.007	0.024	1.007	0.760
OTLEXP	-1.082	0.297	0.339	0.000
OTLPREP	-0.043	0.021	0.958	0.038
OTLDAYS	0.260	0.145	1.296	0.074
OTLSHIFT	-0.495	0.512	0.610	0.334
INSTDEC	-0.044	0.242	0.957	0.857

*Logistic regression: Probability of being assigned to **PROFILE 3 vs. PROFILE 2** as the outcome variable*

Variable	*B*	*SE*	*OR*	*p*
AGE	-0.009	0.015	0.991	0.566
FEMALE	0.356	0.406	1.427	0.381
TEACHEXP	0.010	0.013	1.010	0.447
OTLEXP	0.416	0.477	1.516	0.382
OTLPREP	0.115	0.080	1.122	0.153
OTLDAYS	0.240	0.217	1.271	0.269
OTLSHIFT	-0.506	0.282	0.603	0.073
INSTDEC	0.199	0.256	1.221	0.437

*Logistic regression: Probability of being assigned to **PROFILE 1 vs. PROFILE** 2 as the outcome variable*

Variable	*B*	*SE*	*OR*	*p*
AGE	-0.054	0.018	0.947	0.003
FEMALE	1.133	0.377	3.105	0.003
TEACHEXP	0.032	0.015	1.033	0.029
OTLEXP	-1.020	0.465	0.361	0.028
OTLPREP	0.065	0.082	1.068	0.426
OTLDAYS	-0.385	0.167	0.680	0.021
OTLSHIFT	-0.289	0.397	0.749	0.467
INSTDEC	-0.325	0.192	0.723	0.092

*Logistic regression: Probability of being assigned to **PROFILE 1 vs. PROFILE 3** as the outcome variable*

Variable	*B*	*SE*	*OR*	*p*
AGE	-0.045	0.016	0.956	0.004
FEMALE	0.777	0.462	2.175	0.092
TEACHEXP	0.023	0.018	1.023	0.212
OTLEXP	-1.436	0.404	0.238	0.000
OTLPREP	-0.050	0.056	0.952	0.379
OTLDAYS	-0.625	0.304	0.535	0.040
OTLSHIFT	0.217	0.293	1.242	0.460
INSTDEC	-0.524	0.287	0.592	0.068

Item-Level Descriptive Statistics and Correlations

Means, standard deviations, and correlations with confidence intervals of the items measuring ***TPACK self-efficacy***

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9
1. TCK1	2.70	1.04									
2. TCK2	2.73	1.14	.66** [.58, .73]								
3. TPK1	2.69	1.01	.66** [.58, .73]	.72** [.65, .78]							
4. TPK2	2.53	1.09	.67** [.59, .74]	.73** [.67, .79]	.74** [.67, .79]						
5. TPK3	2.15	1.07	.53** [.42, .61]	.55** [.45, .64]	.55** [.45, .64]	.59** [.50, .67]					
6. TPK4	2.26	1.06	.41** [.29, .51]	.46** [.35, .56]	.50** [.39, .59]	.55** [.46, .64]	.67** [.60, .74]				
7. TPCK1	2.27	1.07	.53** [.43, .62]	.65** [.57, .72]	.66** [.58, .73]	.61** [.51, .68]	.64** [.55, .71]	.60** [.51, .68]			
8. TPCK2	2.09	1.12	.53** [.43, .62]	.59** [.50, .67]	.52** [.41, .61]	.59** [.50, .67]	.56** [.46, .64]	.52** [.42, .61]	.67** [.59, .74]		
9. TPCK3	2.47	1.12	.56** [.46, .64]	.61** [.52, .68]	.57** [.48, .66]	.66** [.58, .73]	.47** [.36, .56]	.49** [.38, .58]	.58** [.48, .66]	.55** [.45, .64]	
10. TPCK4	2.30	1.08	.68** [.60, .74]	.60** [.50, .68]	.63** [.54, .70]	.66** [.58, .73]	.56** [.46, .65]	.49** [.38, .59]	.59** [.50, .67]	.53** [.43, .62]	.62** [.53, .69]

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95 % confidence interval for each correlation. * $p < .05$. ** $p < .01$.

SUPPLEMENTARY MATERIAL S15

Means, standard deviations, and correlations with confidence intervals of the items measuring ***institutional support***

Variable	*M*	*SD*	1	2	3	4	5	6	7
1. PIS1	2.40	1.50							
2. PIS2	2.86	1.44	.73** [.67, .79]						
3. PIS3	2.38	1.42	.79** [.74, .84]	.78** [.73, .83]					
4. PIS4	2.73	1.48	.70** [.62, .76]	.75** [.68, .80]	.74** [.68, .80]				
5. PIS5	2.41	1.49	.64** [.56, .71]	.69** [.61, .75]	.72** [.65, .78]	.74** [.68, .80]			
6. PIS6	2.36	1.56	.74** [.68, .80]	.78** [.72, .82]	.81** [.76, .85]	.78** [.72, .83]	.79** [.73, .83]		
7. PISCO1	2.60	1.62	.54** [.43, .62]	.61** [.52, .69]	.58** [.49, .66]	.70** [.63, .76]	.64** [.55, .71]	.69** [.61, .75]	
8. PISCO2	2.08	1.54	.56** [.46, .64]	.58** [.49, .66]	.67** [.59, .74]	.64** [.56, .71]	.69** [.61, .75]	.68** [.61, .75]	.68** [.60, .74]

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95 % confidence interval for each correlation. * $p < .05$. ** $p < .01$.

SUPPLEMENTARY MATERIAL S16

Means, standard deviations, and correlations with confidence intervals of items measuring ***perceived online teaching presence***

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12
1. POTP1	3.01	0.81												
2. POTP2	3.03	0.79	.81** [.76, .85]											
3. POTP3	2.85	0.91	.68** [.60, .75]	.64** [.55, .71]										
4. POTP4	3.10	0.88	.67** [.60, .74]	.67** [.59, .74]	.67** [.59, .74]									
5. POTP5	2.64	0.91	.53** [.43, .62]	.54** [.44, .63]	.52** [.42, .61]	.44** [.33, .54]								
6. POTP6	2.69	0.93	.55** [.46, .64]	.50** [.40, .60]	.51** [.41, .60]	.47** [.36, .56]	.70** [.62, .76]							
7. POTP7	2.38	0.99	.46** [.35, .56]	.44** [.33, .54]	.48** [.37, .57]	.40** [.28, .51]	.53** [.43, .62]	.62** [.53, .70]						
8. POTP8	2.5	0.93	.48** [.37, .58]	.44** [.33, .54]	.44** [.33, .54]	.45** [.34, .55]	.55** [.45, .64]	.60** [.51, .68]	.76** [.70, .81]					
9. POTP9	2.48	1.02	.40** [.28, .50]	.43** [.32, .53]	.42** [.31, .52]	.41** [.29, .51]	.55** [.45, .63]	.56** [.46, .64]	.61** [.53, .69]	.63** [.54, .70]				
10. POTP10	2.25	1.04	.41** [.29, .51]	.38** [.26, .49]	.45** [.33, .55]	.35** [.22, .46]	.50** [.39, .59]	.51** [.40, .60]	.64** [.55, .71]	.54** [.43, .62]	.56** [.47, .65]			

11. POTP11	2.38	1.05	.50** [.39, .59]	.50** [.39, .59]	.46** [.35, .56]	.48** [.37, .58]	.54** [.44, .63]	.59** [.50, .67]	.65** [.57, .72]	.65** [.56, .72]	.67** [.60, .74]	.69** [.61, .75]		
12. POTP12	2.83	0.94	.46** [.35, .56]	.49** [.38, .58]	.46** [.35, .56]	.41** [.29, .51]	.52** [.42, .61]	.60** [.50, .67]	.45** [.34, .55]	.39** [.27, .50]	.52** [.41, .61]	.44** [.33, .54]	.58** [.49, .66]	
13. POTP13	2.67	0.98	.34** [.22, .45]	.33** [.21, .44]	.37** [.25, .48]	.25** [.12, .37]	.38** [.26, .49]	.45** [.34, .55]	.35** [.23, .46]	.31** [.18, .42]	.37** [.25, .48]	.32** [.19, .43]	.35** [.23, .46]	.58** [.48, .66]

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95 % confidence interval for each correlation. * $p < .05$. ** $p < .01$.

SUPPLEMENTARY MATERIAL S18

Supplementary Material S3

Correlation Matrix

Means, standard deviations, and correlations with confidence intervals

Variable	*M*	*SD*	1	2	3
1. gTPACK	0.00	0.80			
2. gPIS	0.00	1.18	.36** [.24, .47]		
3. PISCO1	2.60	1.62	.34** [.22, .45]	.71** [.64, .77]	
4. PISCO2	2.08	1.54	.37** [.25, .48]	.72** [.65, .78]	.68** [.60, .74]
5. POPGEN	0.00	0.75	.66** [.58, .73]	.35** [.23, .46]	.32** [.19, .43]
6. POPCLA	0.00	0.65	.62** [.53, .69]	.36** [.24, .47]	.34** [.22, .45]
7. POPFED	0.00	0.68	.65** [.56, .72]	.36** [.24, .47]	.33** [.21, .44]
8. AGE	43.46	10.65	-.01 [-.15, .12]	-.07 [-.20, .06]	-.08 [-.21, .05]
9. FEMALE	0.69	0.46	-.11 [-.24, .02]	.05 [-.08, .18]	-.01 [-.14, .12]
10. TEACHEXP	15.27	10.11	.02 [-.12, .15]	-.02 [-.15, .11]	.01 [-.12, .14]
11. OTLEXP	0.26	0.44	.29** [.16, .40]	.01 [-.12, .15]	.04 [-.10, .17]
12. OTLPREP	4.29	11.12	.10 [-.03, .23]	.15* [.02, .28]	.12 [-.02, .25]
13. OTLDAYS	1.63	1.24	.14* [.01, .27]	.03 [-.10, .17]	.03 [-.11, .16]
14. OTLSHIFT	1.63	0.57	.09 [-.04, .22]	-.02 [-.15, .11]	.07 [-.06, .20]
15. INSTDEC	1.61	0.63	.08 [-.05, .22]	.10 [-.03, .23]	.04 [-.09, .18]

Note. M and SD are used to represent mean and standard deviation, respectively. Values i

4	5	6	7	8	9	10
.33**						
[.21, .45]						
.28**	.74**					
[.15, .39]	[.68, .80]					
.33**	.91**	.82**				
[.21, .44]	[.88, .93]	[.78, .86]				
-.10	.03	-.12	-.04			
[-.23, .04]	[-.10, .16]	[-.24, .02]	[-.17, .09]			
-.01	.02	.05	.11	-.11		
[-.14, .12]	[-.11, .15]	[-.08, .18]	[-.02, .24]	[-.24, .03]		
-.01	.02	-.09	-.01	.73**	.02	
[-.14, .13]	[-.11, .16]	[-.22, .04]	[-.14, .12]	[.66, .79]	[-.11, .15]	
.07	.19**	.15*	.12	.03	-.21**	.08
[-.06, .20]	[.06, .32]	[.02, .28]	[-.01, .25]	[-.10, .16]	[-.34, -.08]	[-.05, .21]
.17*	.07	.09	.06	.01	-.15*	.03
[.03, .30]	[-.07, .20]	[-.05, .22]	[-.07, .20]	[-.13, .15]	[-.28, -.01]	[-.10, .17]
.07	.09	.00	.05	-.00	.06	.06
[-.06, .21]	[-.05, .22]	[-.13, .14]	[-.09, .18]	[-.14, .13]	[-.07, .19]	[-.08, .19]
-.09	.01	.15*	.09	.02	.03	.05
[-.22, .05]	[-.12, .14]	[.02, .28]	[-.04, .22]	[-.11, .15]	[-.10, .16]	[-.08, .18]
.03	.04	.09	.11	.04	.21**	.01
[-.11, .16]	[-.10, .17]	[-.05, .22]	[-.02, .24]	[-.09, .18]	[.08, .33]	[-.12, .15]

in square brackets indicate the 95 % confidence interval for each correlation. * $p < .05$. ** $p < .01$

11	12	13	14
.15*			
[.01, .28]			
.05	.25**		
[-.09, .18]	[.12, .37]		
-.04	-.19**	-.13	
[-.17, .10]	[-.32, -.06]	[-.26, .01]	
-.02	-.05	.02	.19**
[-.16, .11]	[-.18, .09]	[-.12, .15]	[.05, .31]

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Supplementary Material S3

Codebook

Variable	Description
AGE	Age in years
FEMALE	Gender with women as the reference
TEACHEXP	Teaching experience in general
OTLEXP	Online teaching experience before the COVID-19 pandemic
OTLPREP	Online teaching preparation
OTLSHIFT	Online teaching shift
OTLDAYS	Days into online teaching after the beginning of COVID-19
INSTDEC	Institutional decision for online teaching and learning
PISCO1	Perceived institutional support due to the COVID-19 pandemic
PISCO2	Perceived institutional support due to the COVID-19 pandemic
gTPACK	General TPACK self-efficacy (factor score)
gPIS	General perceived institutional support (factor score)
POPCLA	Online presence: Instructional clarity (factor score)

POPFED	Online presence: Feedback and assessment (factor score)
POPCOG	Online presence: Cognitive activation (factor score)

Item
What is your age?
How do you identify your gender?
How many years have you been teaching?
Have you been teaching online, before COVID-19?
How many days were you given to prepare your subjects/classes to go online?
As a result of COVID-19, did you have to shift your face-to-face subjects/classes to an online platform?
How much time has passed since you had to transition your subjects/classes online?
To what extent did your institution decide that you need to transition your face-to-face subjects/classes to an online platform?
If your institution has asked you to transition your teaching from face-to-face to online, have you been provided with the following... [Additional technical support has been provided to transition face-to-face teaching to online because of COVID-19.]
If your institution has asked you to transition your teaching from face-to-face to online, have you been provided with the following... [Additional pedagogical support has been provided to transition face-to-face teaching to online because of COVID-19.]
Factor score based on items TCK1-TPCK4
Factor score based on items PIS1-PIS6
Factor score based on items POTP1-POTP4

Factor score based on items POTP5-POTP6, POTP12-POTP13

Factor score based on items POTP7-POTP11

Levels	Construct/Domain
Numeric in years	Background
1=Female, 0=Male, NA=prefer not to say or missing	Background
Numeric in years	Background
1=Yes, 0=No	OTL
Numeric in days	OTL
0=No, none of it. 1=Some of my teaching, 2=Yes, all of it.	OTL
0=Less than 1 week, 1=1-2 weeks, 2=2-4 weeks, 3=1-2 months, 4=2-4 months, 5=4-6 months, 6=Over half a year ago.	OTL
0=It was not mandatory, 1=It was expected, 2=It was mandatory	OTL
0=completely disagree, 1=disagree, 2=disagree more than agree, 3=agree more than disagree, 4=agree, 5=completely agree	Institutional support
0=completely disagree, 1=disagree, 2=disagree more than agree, 3=agree more than disagree, 4=agree, 5=completely agree	Institutional support
Numeric (factor score)	TPACK
Numeric (factor score)	Institutional support
Numeric (factor score)	Online presence

Numeric (factor score)	Online presence
Numeric (factor score)	Online presence

Level	Source
Participant	Primary
Participant	Primary
Participant	Primary
Participant	Primary
Participant	Primary
Participant	Primary
Participant	Primary
Participant	Primary
Participant	Primary
Participant	Primary
Participant	Primary
Participant	Primary

Participant	Primary
Participant	Primary

Latent Profile Analysis

Summary

Model	k	LL	Npar	SCF	AIC	BIC
Total sample (*N*=222)						
One profile	1	-2139.006	14	1.0201	4306.012	4353.649
Two profiles	2	-1888.273	29	1.1282	3834.547	3933.224
Three profiles	3	-1731.877	44	0.8431	3551.753	3701.471
Four profiles	4	-1642.848	59	0.8146	3403.695	3604.453
Five profiles	5	-1549.075	74	0.9864	3246.150	3497.948
Six profiles	6	-1482.811	89	0.8325	3143.622	3446.460

Suggestion:

Accept the model with 4 profiles.

Reasoning:

Although the model with three profiles is statistically preferred with respect to some indic

aBIC	Entropy	p(VLMR-LRT)	p(LMR-LRT)
4309.282	1.000	-	-
3841.321	0.857	0.3061	0.309
3562.031	0.921	0.0461	0.0474
3417.477	0.924	0.2398	0.2413
3263.436	0.935	1.0000	1.0000
3164.412	0.926	1.0000	1.0000

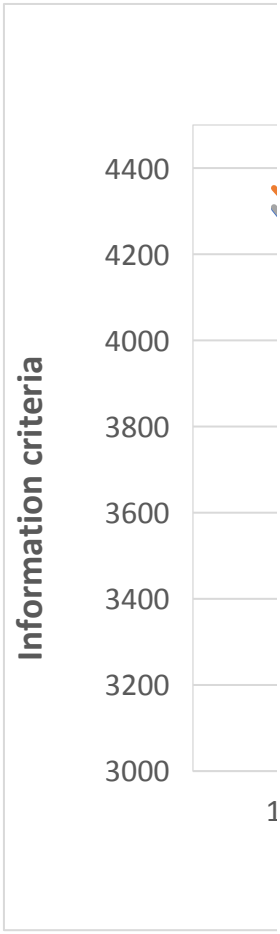
cators, the four-profile model adds a substantively meanir

Notes
Baseline model
Two groups: n1=82 (low), n2=140 (high)
Three groups: n1=115, n2=77, n3=30
Smallest group: 13.6 %; groups distinguishable; one group not captured by the three profiles
Smallest group: 4.7 %; some groups very similar
Smallest group: 4.4 %; some groups very similar

ŋgful profile of substantial size.

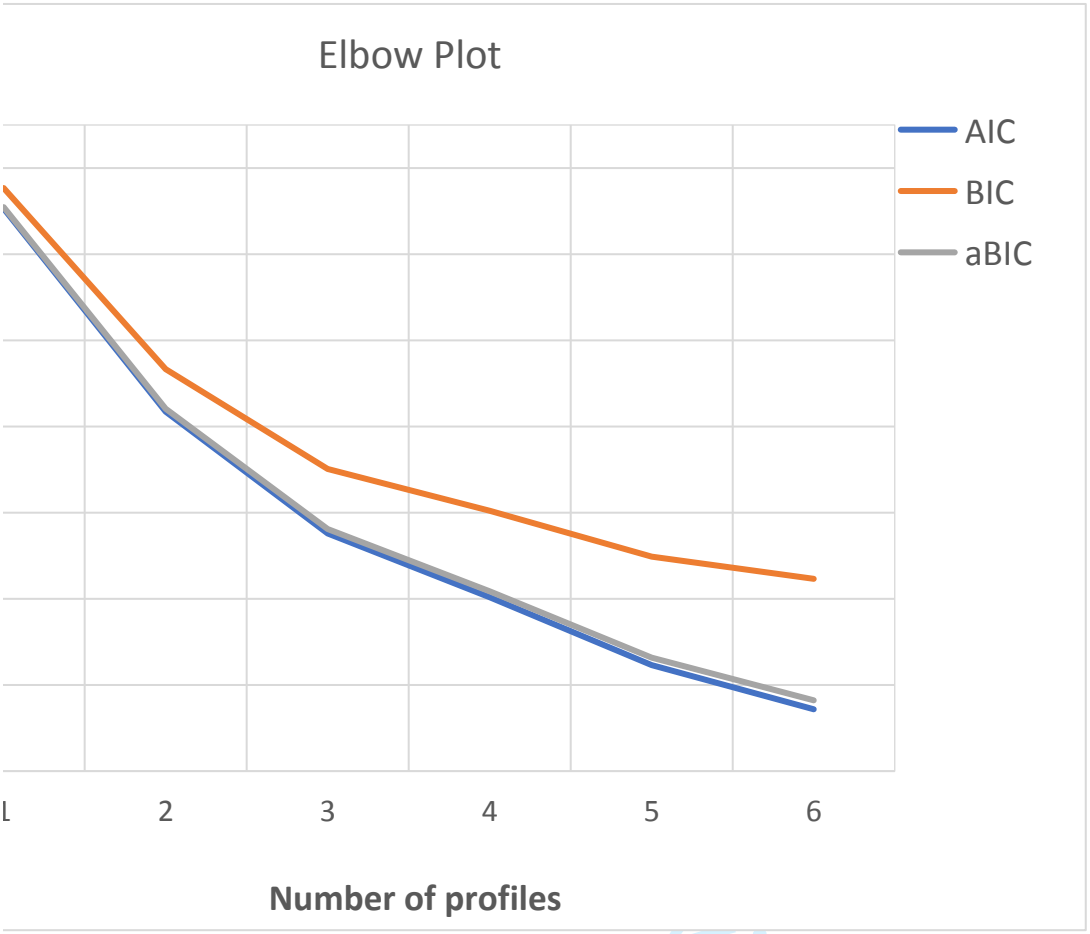
Elbow Plot

Number of profiles	AIC	BIC	aBIC
1	4306.012	4353.649	4309.282
2	3834.547	3933.224	3841.321
3	3551.753	3701.471	3562.031
4	3403.695	3604.453	3417.477
5	3246.150	3497.948	3263.436
6	3143.622	3446.460	3164.412



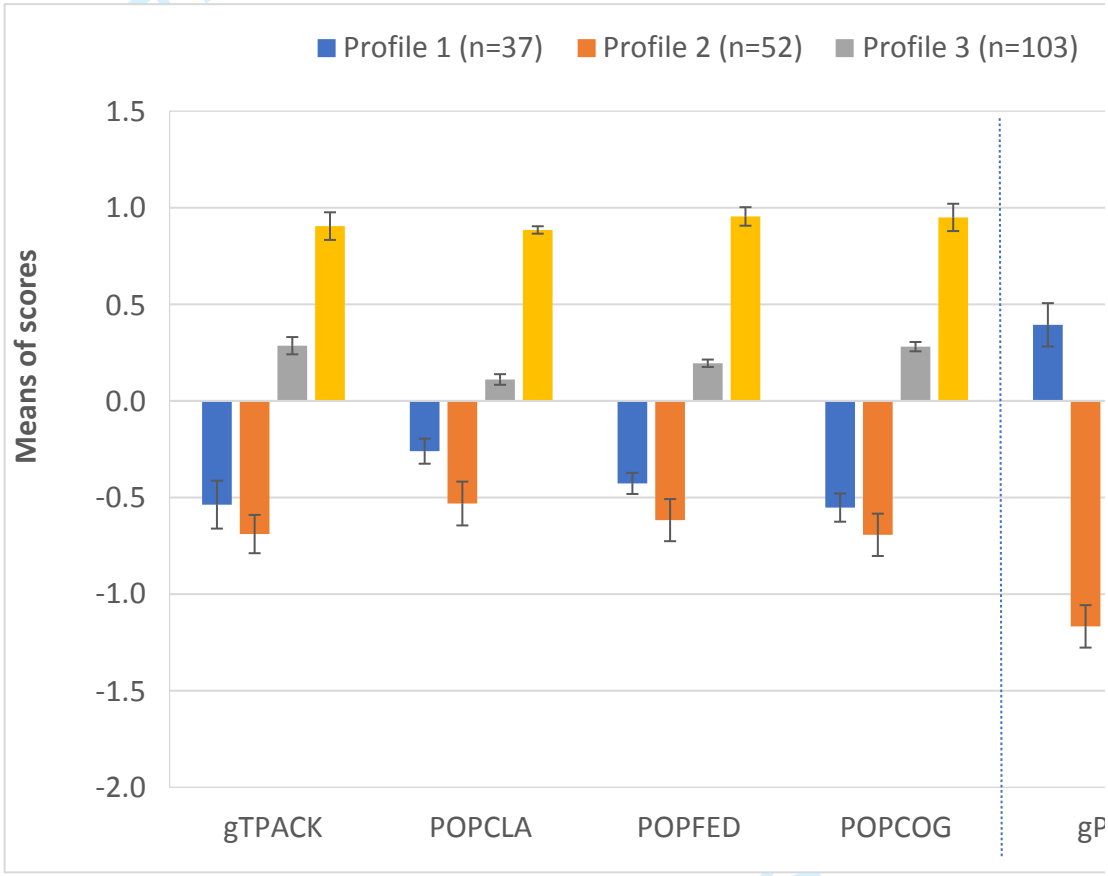
Notes:

The plot suggests a solution with 3 or 4 profiles.



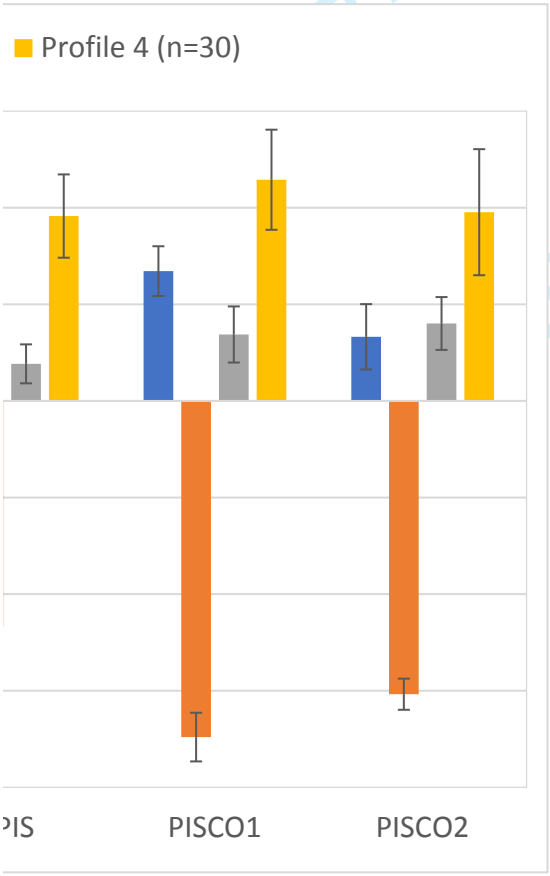
under

Means	Profile 1 (*n*=37)	Profile 2 (*n*=52)	Profile 3 (*n*=103)	Profile 4 (*n*=30)	**Variances**
gTPACK	-0.537	-0.689	0.286	0.905	gTPACK
POPCLA	-0.26	-0.531	0.111	0.885	POPCLA
POPFED	-0.427	-0.617	0.195	0.955	POPFED
POPCOG	-0.552	-0.693	0.281	0.95	POPCOG
gPIS	0.394	-1.167	0.192	0.957	gPIS
PISCO1	0.672	-1.74	0.344	1.145	PISCO1
PISCO2	0.332	-1.518	0.401	0.977	PISCO2



Profile 1	Profile 2	Profile 3	Profile 4
0.567	0.512	0.205	0.153
0.156	0.669	0.078	0.011
0.11	0.617	0.038	0.069
0.198	0.624	0.06	0.15
0.466	0.627	1.047	1.395
0.613	0.825	2.172	2.014
1.059	0.338	1.924	3.193

SE	Profile 1
gTPACK	0.12379145
POPCLA	0.0649324
POPFED	0.05452498
POPCOG	0.07315293
gPIS	0.11222564
PISCO1	0.12871506
PISCO2	0.16917926



Profile 2	Profile 3	Profile 4
0.09922779	0.04461268	0.07141428
0.11342568	0.02751875	0.01914854
0.10892835	0.0192076	0.04795832
0.10954451	0.02413554	0.07071068
0.10980752	0.10082187	0.21563859
0.12595787	0.14521494	0.25910101
0.08062258	0.13667338	0.32624122

Size	Profile 1	Profile 2
N	37	52
[%]	16.67%	23.42%

Profile 3	Profile 4
103	30
46.40%	13.51%

Predictors of profile membership at the participant level

PROFILE 4 as the reference

Logistic regression: Probability of being assigned to **PROFILE 1 vs. PROF**

Variable	B	SE	OR	p	Predictor
AGE	-0.028	0.014	0.972	0.038	Yes
FEMALE	0.146	0.297	1.157	0.623	No
TEACHEXP	0.036	0.022	1.036	0.102	No
OTLEXP	-2.399	0.420	0.091	0.000	Yes
OTLPREP	-0.070	0.072	0.932	0.331	No
OTLDAYS	-0.297	0.253	0.743	0.239	No
OTLSHIFT	-0.099	0.612	0.906	0.872	No
INSTDEC	-0.651	0.356	0.522	0.067	Yes

Logistic regression: Probability of being assigned to **PROFILE 2 vs. PROF**

Variable	B	SE	OR	p	Predictor
AGE	0.030	0.021	1.031	0.147	No
FEMALE	-1.069	0.278	0.343	0.000	Yes
TEACHEXP	-0.006	0.021	0.994	0.763	No
OTLEXP	-1.726	0.544	0.178	0.002	Yes
OTLPREP	-0.174	0.114	0.840	0.128	No
OTLDAYS	0.018	0.232	1.018	0.938	No
OTLSHIFT	-0.042	0.578	0.959	0.943	No
INSTDEC	-0.251	0.291	0.778	0.387	No

Logistic regression: Probability of being assigned to **PROFILE 3 vs. PROF**

Variable	B	SE	OR	p	Predictor
AGE	0.014	0.024	1.014	0.558	No
FEMALE	-0.689	0.569	0.502	0.226	No
TEACHEXP	0.005	0.024	1.005	0.835	No
OTLEXP	-0.996	0.294	0.369	0.001	Yes
OTLPREP	-0.046	0.023	0.955	0.040	Yes
OTLDAYS	0.256	0.122	1.292	0.035	Yes
OTLSHIFT	-0.475	0.505	0.622	0.347	No
INSTDEC	-0.021	0.264	0.979	0.936	No

PROFILE 2 as the reference

Logistic regression: Probability of being assigned to **PROFILE 3 vs. PROF**

Variable	B	SE	OR	p	Predictor
AGE	-0.016	0.012	0.984	0.180	No
FEMALE	0.381	0.412	1.464	0.355	No
TEACHEXP	0.011	0.016	1.011	0.476	No
OTLEXP	0.730	0.392	2.075	0.062	Yes

OTLPREP	0.128	0.107	1.136	0.234	No
OTLDAYS	0.238	0.252	1.269	0.344	No
OTLSHIFT	-0.433	0.231	0.648	0.061	Yes
INSTDEC	0.230	0.299	1.259	0.442	No

Logistic regression: Probability of being assigned to **PROFILE 1 vs. PROF**

Variable	B	SE	OR	p	Predictor
AGE	-0.059	0.017	0.943	0.001	Yes
FEMALE	1.216	0.324	3.372	0.000	Yes
TEACHEXP	0.042	0.014	1.043	0.003	Yes
OTLEXP	-0.674	0.382	0.510	0.078	Yes
OTLPREP	0.104	0.111	1.110	0.347	No
OTLDAYS	-0.316	0.149	0.729	0.035	Yes
OTLSHIFT	-0.057	0.441	0.945	0.897	No
INSTDEC	-0.399	0.193	0.671	0.039	Yes

PROFILE 3 as the reference

Logistic regression: Probability of being assigned to **PROFILE 1 vs. PROF**

Variable	B	SE	OR	p	Predictor
AGE	-0.042	0.021	0.959	0.039	Yes
FEMALE	0.835	0.470	2.304	0.076	Yes
TEACHEXP	0.030	0.014	1.031	0.030	Yes
OTLEXP	-1.403	0.217	0.246	0.000	Yes
OTLPREP	-0.024	0.052	0.976	0.648	No
OTLDAYS	-0.554	0.285	0.575	0.052	Yes
OTLSHIFT	0.377	0.373	1.457	0.312	No
INSTDEC	-0.630	0.404	0.533	0.119	No

4-Profile Solution: Indirect-Inclusion Approach (R3STEP) Multinomial logistic regr

FILE 4 as the outcome variable

Interpretation
Older participants were less likely to be assigned to profile 1.
-
-
The more experience with OTL participants had, the less likely they were assigned to profile 1.
-
-
-
The more enforced the transition to OTL was, the less likely participants were assigned to profile

FILE 4 as the outcome variable

Interpretation
-
Men were more likely to be assigned to profile 2.
-
The more experience with OTL participants had, the less likely they were assigned to profile 2.
-
-
-
-

FILE 4 as the outcome variable

Interpretation
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-
The more experience with OTL participants had, the less likely they were assigned to profile 3.
The more experience with OTL participants had, the less likely they were assigned to profile 3.
Participants who had spent more days with OTL since the transition were more likely to be assigr
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-

FILE 2 as the outcome variable

Interpretation
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The more experience with OTL participants had, the more likely they were assigned to profile 3.

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-
Teachers who had to shift only some of their teaching to OTL were more likely to be in profile 3.
-

FILE 2 as the outcome variable

Interpretation
Younger teachers were more likely to be assigned to profile 1.
Female teachers were more likely to be assigned to profile 1.
Teachers who had more teaching experience were more likely to be assigned to profile 1.
Teachers who had less experience with OTL were more likely to be assigned to profile 1.
-
Teachers who had been into OTL since the transition more days were less likely to be assigned to
-
Teachers for whom the transition was not mandatory were more likely to be assigned to profile 1

FILE 3 as the outcome variable

Interpretation
Younger teachers were more likely to be assigned to profile 1.
Female teachers were more likely to be assigned to profile 1.
The more experienced teachers were, the more likely they were assigned to profile 1.
Teachers who had less experience with OTL were more likely to be assigned to profile 1.
Teachers who had been into OTL since the transition more days were less likely to be assigned to
-
Teachers for whom the transition was not mandatory were more likely to be assigned to profile 1

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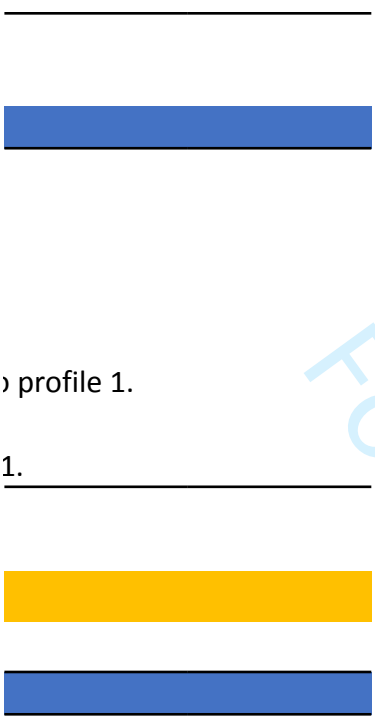

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Predictors of profile membership at the participant level

PROFILE 4 as the reference

Logistic regression: Probability of being assigned to **PROFILE 1 vs. PROF**

Variable	B	SE	OR	p	Predictor
AGE	-0.030	0.013	0.971	0.020	Yes
FEMALE	0.088	0.297	1.092	0.767	No
TEACHEXP	0.030	0.022	1.030	0.164	No
OTLEXP	-2.518	0.520	0.081	0.000	Yes
OTLPREP	-0.092	0.076	0.912	0.221	No
OTLDAYS	-0.365	0.227	0.694	0.108	No
OTLSHIFT	-0.278	0.639	0.757	0.663	No
INSTDEC	-0.567	0.305	0.567	0.063	Yes

Logistic regression: Probability of being assigned to **PROFILE 2 vs. PROF**

Variable	B	SE	OR	p	Predictor
AGE	0.024	0.024	1.025	0.308	No
FEMALE	-1.045	0.318	0.352	0.001	Yes
TEACHEXP	-0.002	0.020	0.998	0.904	No
OTLEXP	-1.498	0.673	0.224	0.026	Yes
OTLPREP	-0.158	0.090	0.854	0.080	Yes
OTLDAYS	0.020	0.189	1.020	0.916	No
OTLSHIFT	0.011	0.624	1.011	0.986	No
INSTDEC	-0.243	0.311	0.784	0.435	No

Logistic regression: Probability of being assigned to **PROFILE 3 vs. PROF**

Variable	B	SE	OR	p	Predictor
AGE	0.016	0.022	1.016	0.465	No
FEMALE	-0.689	0.536	0.502	0.199	No
TEACHEXP	0.007	0.024	1.007	0.760	No
OTLEXP	-1.082	0.297	0.339	0.000	Yes
OTLPREP	-0.043	0.021	0.958	0.038	Yes
OTLDAYS	0.260	0.145	1.296	0.074	Yes
OTLSHIFT	-0.495	0.512	0.610	0.334	No
INSTDEC	-0.044	0.242	0.957	0.857	No

PROFILE 2 as the reference

Logistic regression: Probability of being assigned to **PROFILE 3 vs. PROF**

Variable	B	SE	OR	p	Predictor
AGE	-0.009	0.015	0.991	0.566	No
FEMALE	0.356	0.406	1.427	0.381	No
TEACHEXP	0.010	0.013	1.010	0.447	No
OTLEXP	0.416	0.477	1.516	0.382	No

OTLPREP	0.115	0.080	1.122	0.153	No
OTLDAYS	0.240	0.217	1.271	0.269	No
OTLSHIFT	-0.506	0.282	0.603	0.073	Yes
INSTDEC	0.199	0.256	1.221	0.437	No

Logistic regression: Probability of being assigned to **PROFILE 1 vs. PROF**

Variable	B	SE	OR	p	Predictor
AGE	-0.054	0.018	0.947	0.003	Yes
FEMALE	1.133	0.377	3.105	0.003	Yes
TEACHEXP	0.032	0.015	1.033	0.029	Yes
OTLEXP	-1.020	0.465	0.361	0.028	Yes
OTLPREP	0.065	0.082	1.068	0.426	No
OTLDAYS	-0.385	0.167	0.680	0.021	Yes
OTLSHIFT	-0.289	0.397	0.749	0.467	No
INSTDEC	-0.325	0.192	0.723	0.092	Yes

PROFILE 3 as the reference

Logistic regression: Probability of being assigned to **PROFILE 1 vs. PROF**

Variable	B	SE	OR	p	Predictor
AGE	-0.045	0.016	0.956	0.004	Yes
FEMALE	0.777	0.462	2.175	0.092	Yes
TEACHEXP	0.023	0.018	1.023	0.212	No
OTLEXP	-1.436	0.404	0.238	0.000	Yes
OTLPREP	-0.050	0.056	0.952	0.379	No
OTLDAYS	-0.625	0.304	0.535	0.040	Yes
OTLSHIFT	0.217	0.293	1.242	0.460	No
INSTDEC	-0.524	0.287	0.592	0.068	Yes

4-Profile Solution: Direct-Inclusion Approach	Multinomial logistic regr

FILE 4 as the outcome variable

Interpretation
Older participants were less likely to be assigned to profile 1.
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-
The more experience with OTL participants had, the less likely they were assigned to pro
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-
The more enforced the transition to OTL was, the less likely participants were assigned t

FILE 4 as the outcome variable

Interpretation
-
Men were more likely to be assigned to profile 2.
-
The more experience with OTL participants had, the less likely they were assigned to pro
The more preparation time participants had been given for OTL, the less likely they were
-
-
-

FILE 4 as the outcome variable

Interpretation
-
-
-
The more experience with OTL participants had, the less likely they were assigned to pro
The more experience with OTL participants had, the less likely they were assigned to pro
Participants who had spent more days with OTL since the transition were more likely to
-
-

FILE 2 as the outcome variable

Interpretation
-
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Teachers who had to shift only some of their teaching to OTL were more likely to be in p
-

FILE 2 as the outcome variable

Interpretation
Younger teachers were more likely to be assigned to profile 1.
Female teachers were more likely to be assigned to profile 1.
Teachers who had more teaching experience were more likely to be assigned to profile 1
Teachers who had less experience with OTL were more likely to be assigned to profile 1.
-
Teachers who had been into OTL since the transition more days were less likely to be ass
-
Teachers for whom the transition was not mandatory were more likely to be assigned to

FILE 3 as the outcome variable

Interpretation
Younger teachers were more likely to be assigned to profile 1.
Female teachers were more likely to be assigned to profile 1.
-
Teachers who had less experience with OTL were more likely to be assigned to profile 1.
Teachers who had been into OTL since the transition more days were less likely to be ass
-
Teachers for whom the transition was not mandatory were more likely to be assigned to

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