Confirmatory factor analysis (CFA) of multivariate lipid distributions across time and race-ethnic groups: United States, 2003-2012

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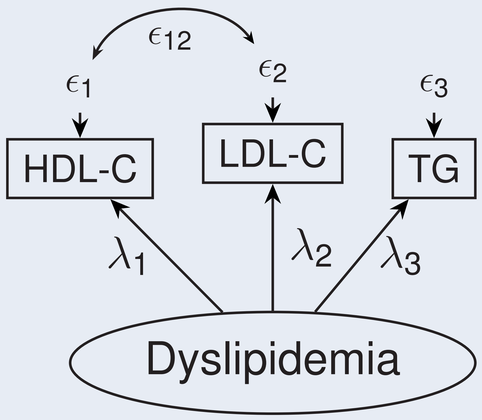
Introduction

- High density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C) and triglycerides (TG) are common measures of dyslipidemia.
  - Common analytic practice includes separate evaluations of each lipoprotein when evaluating dyslipidemia.
  - An alternative is to specify one latent factor, which predicts lipid values and incorporates their covariance structure.
- Before using the latent factor, important to determine if underlying structure of dyslipidemia construct is similar across groups (measurement invariance).
  - For example, do racial/ethnic groups have the same construct?

Aims

1. Estimate dyslipidemia in a U.S. representative sample (NHANES) as one latent factor with three indicators (HDL-C, LDL-C, TG) via confirmatory factor analysis (CFA).
2. Test similarity of latent factor parameters (measurement invariance) across age and racial/ethnic groups.

Methods: CFA



Equations for CFA:

$$\begin{cases} \text{HDL-C} = \mu_1 + \lambda_1\eta_1 + \epsilon_1 \\ \text{LDL-C} = \mu_2 + \lambda_2\eta_1 + \epsilon_2 \\ \text{TG-C} = \mu_3 + \lambda_3\eta_1 + \epsilon_3 \end{cases}$$

⇒ Evaluate model fit across year and racial/ethnic groups in four models, holding different parameters constant.

Methods, cont...

- Factor loadings, λ, represent the association between lipids and the latent factor for dyslipidemia, η_1.
- Intercepts, μ, represent the means of the indicators, lipids.

Four models[a]

Model 1 Test metric invariance: equal factor loadings but different intercepts across groups.

Model 2 Test intercept-only invariance: different factor loadings but equal intercepts across groups

Model 3 Test scalar invariance: equal factor loadings and equal intercepts across groups

Model 4 Full uniqueness invariance: equal loadings, intercept and variance across all groups

[a] All models include body mass index (BMI) and age covarying with factor (not shown in figure).

Results, 12-19 years

Model fit information

Model	Chi-sq	df	LL	CFI	BIC	RMSEA
Groups: Race/Ethnicity						
1	118	49	-54014	0.946	108452	0.042
2	245	45	-54117	0.844	108690	0.075
3	1457	57	-55136	0.000	110628	0.176
4	276	57	-54143	0.829	108643	0.070
Groups: Time (year)						
1	110	49	-53436	0.931	107294	0.040
2	134	45	-53457	0.899	107370	0.050
3	1234	60	-54538	0.000	109408	0.157
4	147	57	-53470	0.897	107296	0.045

Racial/ethnic groups

- Model 1, allowing intercepts to vary, offers best fit.
  - Acceptable levels include Root Mean Square Error of Approximation (RMSEA) < 0.05, Comparative Fit Index (CFI) = 0.95 and lowest Bayesian Information Criterion (BIC) of all models.

Time groups

- Model 1, allowing intercepts to vary, offers best fit.
  - RMSEA < 0.05, CFI = 0.93 and lowest Bayesian Information Criterion (BIC) of all models.

Results, 12-19 years, cont...

Lipid construct comparisons across:

Racial/ethnic groups Evidence for metric non-invariance (χ^2(df)=155 (8), p-value<0.001) ⇒ Cannot make meaningful comparisons across racially and ethnically diverse populations.

Time (years) Evidence for metric non-invariance (χ^2(df)=155 (12), p-value<0.001) ⇒ Cannot make meaningful comparisons across time.

Model 1 standardized parameters by race/ethnic groups

Parameter	HDL-C	LDL-C	TG
Mexican American			
Loading	-0.681 (0.027)	0.436 (0.038)	0.598 (0.024)
Intercept	-0.142 (0.035)	-0.874 (0.049)	-0.549 (0.036)
Residual variance	0.537 (0.037)	0.81 (0.033)	0.643 (0.028)
Non-Hispanic Black			
Loading	-0.596 (0.026)	0.374 (0.032)	0.598 (0.024)
Intercept	0.132 (0.031)	-0.692 (0.04)	-1.078 (0.04)
Residual variance	0.645 (0.031)	0.86 (0.024)	0.643 (0.028)
Non-Hispanic White			
Loading	-0.64 (0.026)	0.381 (0.035)	0.598 (0.024)
Intercept	-0.165 (0.036)	-0.697 (0.053)	-0.539 (0.035)
Residual variance	0.591 (0.033)	0.855 (0.027)	0.643 (0.028)
Other Hispanic			
Loading	-0.676 (0.035)	0.484 (0.045)	0.598 (0.024)
Intercept	-0.162 (0.078)	-1.07 (0.099)	-0.453 (0.083)
Residual variance	0.542 (0.047)	0.766 (0.044)	0.643 (0.028)

Latent factor characteristics:

Factor loadings A one unit factor increase represents less favorable lipid value ⇒ an increase in LDL-C (0.4) and TG (0.6) accompanied by a decrease in HDL ($\sim$ -0.6).

Intercepts Non-Hispanic Black group only one with positive HDL-C (0.132) and lowest TG (-1.078) relative to center of multivariate distribution.

Summary

⇒ 3-indicator latent factor can function as a parsimonious and well-fitting measure for dyslipidemia in structural equation models.

⇒ Cannot compare latent factor across groups by race/ethnic or time status.

References

(1) R. van de Schoot et al. "A checklist for testing measurement invariance". In: *European Journal of Developmental Psychology* 9.4 (July 2012), pp. 486–492. DOI: 10.1080/17405629.2012.686740

(2) T. A. Brown. *Confirmatory factor analysis for applied research*. Second edition. Methodology in the social sciences. New York ; London: The Guilford Press, 2015. 462 pp.

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