

# A Bayesian Multivariate Multilevel Gaussian Model with a Mixed Effects Structure in the Mean and Covariance Part

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## Aims

Burnout among nurses is a major problem in hospitals and may negatively affect patient care. In the European multi-country RN4CAST study, burnout was recorded through a questionnaire together with system-level and nurse-level variables. Burnout is classically expressed with three measurements obtained from a 22-item Likert scale and assumed to represent well the complexity of the burnout problem. However, these three dimensions were determined in a single population in the US in 1996. The question is whether these three dimensions have the same meaning in the European countries involved in the RN4CAST study. To this end we explored the stability of the covariance matrix (and more precisely the intrinsic correlation) between the three burnout dimensions across countries, hospitals, nursing units and nurses.

## Methods

We propose a Bayesian multivariate multilevel factor model that assumes a mixed model for both the mean and the covariance matrix. It also allows for level-specific covariates in the mean structure and covariance matrix. Our model could be seen as an extension of Hoff and Niu's covariance regression model in different ways, namely to a multilevel settings including random effects in the covariance matrix and analyzed in a Bayesian way. A mixture normal prior for the factor loading is needed to obtain the correct estimates. Pseudo Bayes Factor (PSBF) is calculated for model comparison.

## Results

The suggested model allows exploring factors that determine both the mean as well as the covariance structure in a multilevel setting and is robust against outliers. For the RN4CAST study, we concluded that the covariance matrix among the three burnout dimensions varies across countries, hospitals and nursing units, and it also varies according to nurses' working experience and work environment. The two covariates together with the type of nursing unit are also found to be closely related to the mean of burnout.

## Conclusion

Our modeling provides a way to screen and explicitly model the heterogeneity in a multivariate multilevel circumstance in Bayesian way. It allows a mixed structure in both the mean and covariance part. The interpretation of both the fixed and random effects in both the mean and covariance part is also intuitive.