Modeling multivariate multilevel continuous responses with a hierarchical regression model for the mean and covariance matrix applied to a large nursing data set

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We propose a novel multivariate multilevel model that expresses both the mean and covariance structure as a multivariate mixed effects model. We called this the multilevel covariance regression (MCR) model. Two versions of this model are presented. In the first version the covariance matrix of the multivariate response is allowed to depend on covariates and random effects. In this model the random effects of the covariance part are assumed to be independent of random effects of the mean structure. In the second model this assumption is relaxed by allowing the two types of random effects to be dependent. The motivating data set is obtained from the RN4CAST (Sermeus et al. 2011) FP7 project which involves 33,731 registered nurses in 2,169 nursing units in 486 hospitals in 12 European countries. As response we have taken the three classical burnout dimensions (Maslach and Jackson, 1981) extracted from a 22-item questionnaire, i.e. emotional exhaustion (EE), depersonalization (DP) and personal accomplishment (PA). There are four levels in the total data set: nurses, nursing units, hospitals and (for the whole data set) countries. The first model is applied to the total data set, while the second model is applied to only the Belgian part of the data. The two models address the following nurse research questions simultaneously: 1) how much variation of burnout could be explained by the level-specific fixed and random effects? 2) do the variances and correlations among burnout stay constant across level-specific characteristics and units at each level? The two models are explored with respect to their statistical properties, but are also compared on the Belgian part of the study. We opted for the Bayesian approach to estimate the parameters of the model. To this end we made use of the JAGS Markov chain Monte Carlo program through the R package rjags.