Bayesian Hierarchical Models for Personalized Health Care

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Background
Health care data often has a hierarchical structure with observations at different group levels (e.g., regions, hospitals, patients). Most commonly applied statistical models either combine the data to estimate an average effect (complete pooling) or partition the data to estimate a separate effect for each group (no pooling). Such models treat the between-group variance implicitly as either zero (i.e., complete pooling) or infinity (i.e., no pooling).

Aims
We seek statistical models that balance the trade-off between zero and infinite between-group variance and, as a result, incorporate both between- and within-group information in the group-level estimates.

Methods
Bayesian hierarchical models account for the uncertainty in the estimate of the between-group variance through partial pooling. That is, group-level effects are estimated by taking into account the uncertainty about the estimates. For groups with few observations (or few information), the estimates are closer to the estimate from complete pooling. Instead, for groups with many observations, the estimates are closer to the estimate from no pooling. This principle is called shrinkage and can be thought of as pulling group-level estimates towards the population mean when uncertainty in the estimate is high.

Results
We apply Bayesian hierarchical models in different contexts of personalized health care. Thereby, hierarchical models reveal that patient-specific effects can be estimated precisely for patients with many observations, while the estimate for patients with few observations are pulled towards the patient-average.

Conclusion
Our applications demonstrate the advantages of Bayesian hierarchical models for personalized health care. Results from such models entail important implications for medical practitioners. They inform physicians about patients where personalized treatment is more likely to be successful and, vice versa, where a common treatment should rather be administered because the range of possible treatment effects is too large.

Keywords
Bayesian hierarchical models, patient-specific effects, personalized health care