# Towards personalized burnout prevention system: A probabilistic approach for analysis of wearable and contextual data


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## Background & Objectives

In recent years, wearable devices have become widely adopted by the population. Continuously collected physiological data, enriched with implicit and explicit contextual information, are an extremely valuable and often under-estimated, source of information. Statistical algorithms exploiting data from multiple sources, fine-tuned to the singular peculiarity, could be beneficial for various healthcare and social-related research projects.

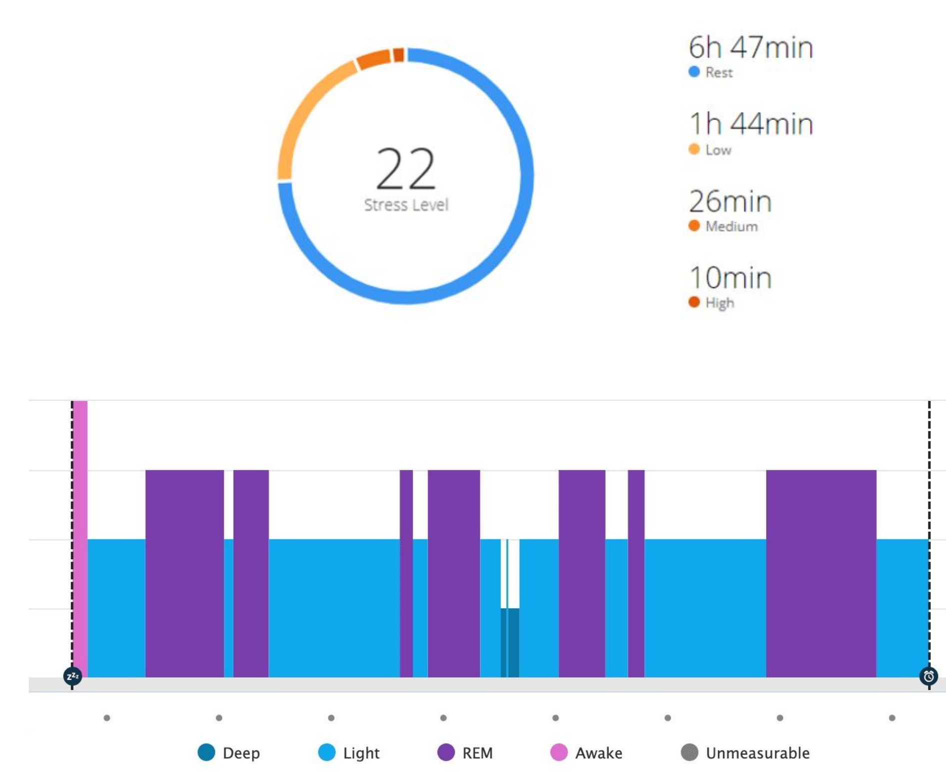
In the present analysis, we aim at a better understanding of how daily lifestyle factors and physiological data contribute to the coping capability of an individual and how changes in behavior could, in the long term, lead to burnout. We exploit the proportions of sleep stages and of nocturnal stress levels as outcome variables related to coping capability.

## Study design

The data were collected during one week, by 16 participants (2 women) of the age between 24 - 44 years, all workers of SUPSI university from 3 different research institutes:

- Subject-specific information collected during onboarding
- **Shirom-Melamed Burnout Measure** (SMBM): a standardized questionnaire to assess the burn-out level
- Objective data from **wearable devices** collected by continuous monitoring:
    - Stress (0-100), heart rate, breathing rate
    - Proportions of sleep stages (Deep, REM, Awake, Light)
    - Activity data: daily steps and active time in various activity levels
- **Explicit contextual information** collected by daily questionnaires
    - Stress, mood, energy
    - Alcohol intake
    - Work-related questions: stress during commuting, working hours
- **Implicit contextual information** derived from calendar and digital biomarkers

### Wearables data




## Bayesian linear mixed-effect model

Linear multivariate mixed-effect model with individual-specific random intercept was applied to predict the longitudinal outcomes **Y**, i.e. alr-transformed proportions of sleep stages and nocturnal stress levels, as:

$$\mathbf{Y} = \mathbf{X}\beta + \mathbf{Z}\mathbf{u} + \epsilon$$

where **X**, **Z** are design matrices of longitudinal observations, and random intercepts, respectively. Further, $\beta$, **u** denote vectors of regression coefficients, and random intercepts. The regression coefficients are estimated in a Bayesian way.

### Compositional outcome variable

**The compositional outcomes** were transformed as an additive log-ratio (ALR):

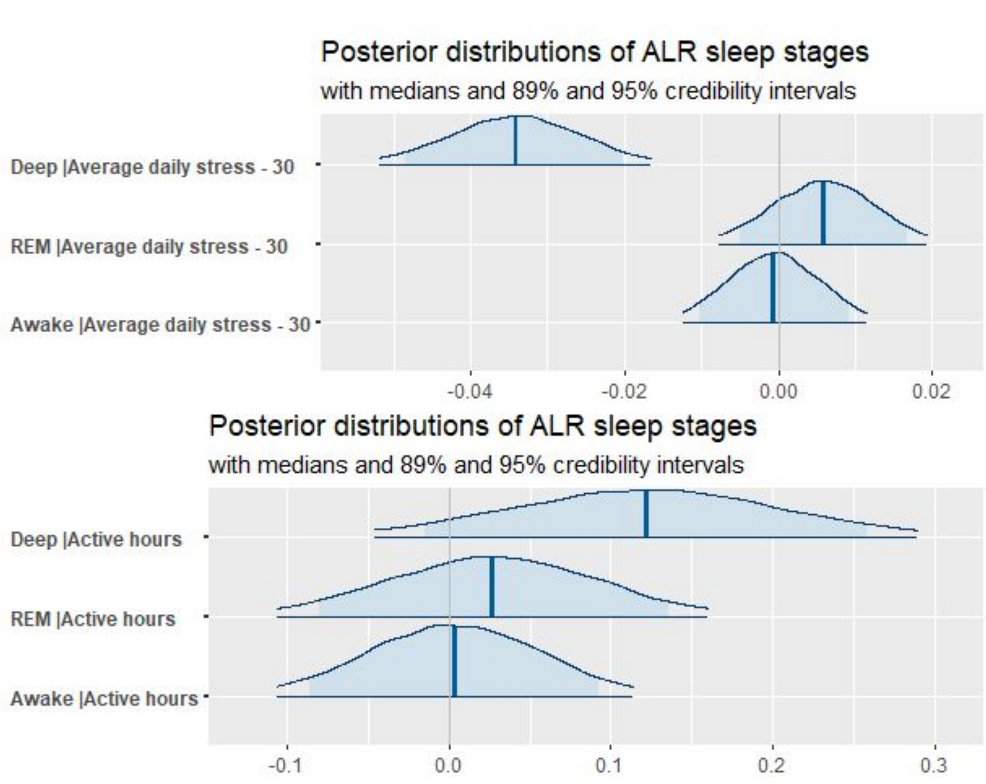
$$\mathrm{alr}(p) = \left[\log \frac{p_1}{p_D}, \cdots, \log \frac{p_{D-1}}{p_D}\right]$$

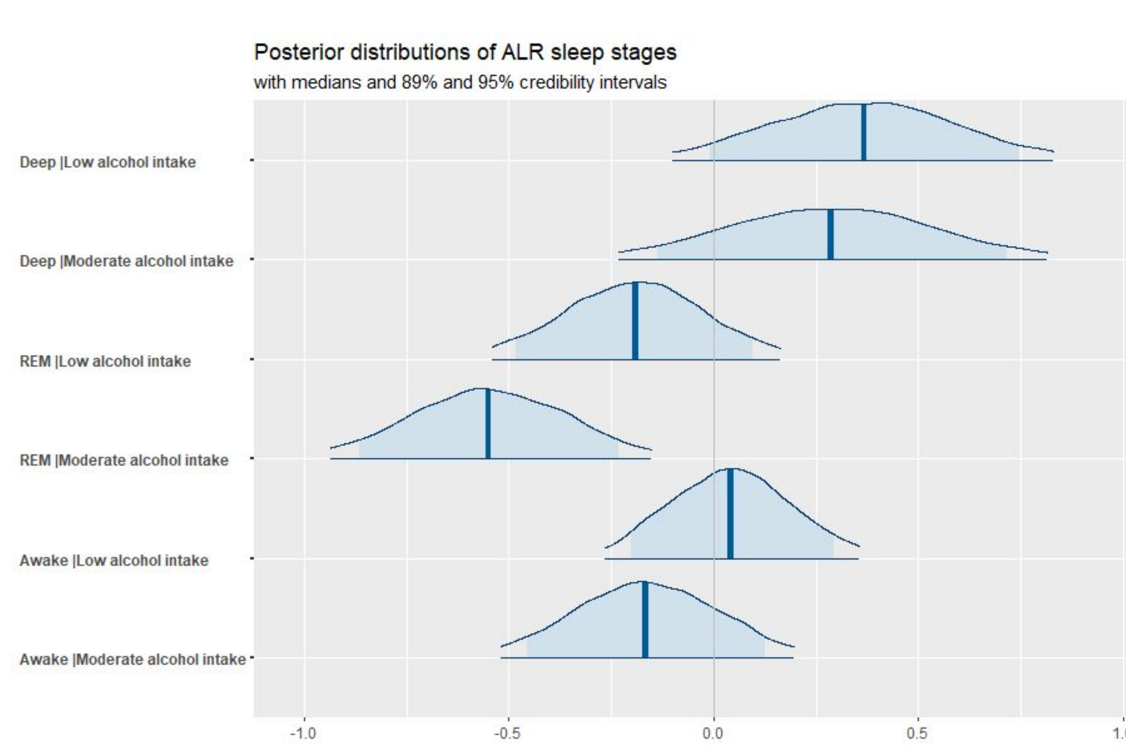
where $p_D$ component is used as a baseline. The log-transformation ensures the outcome variable to be nearly normally distributed.

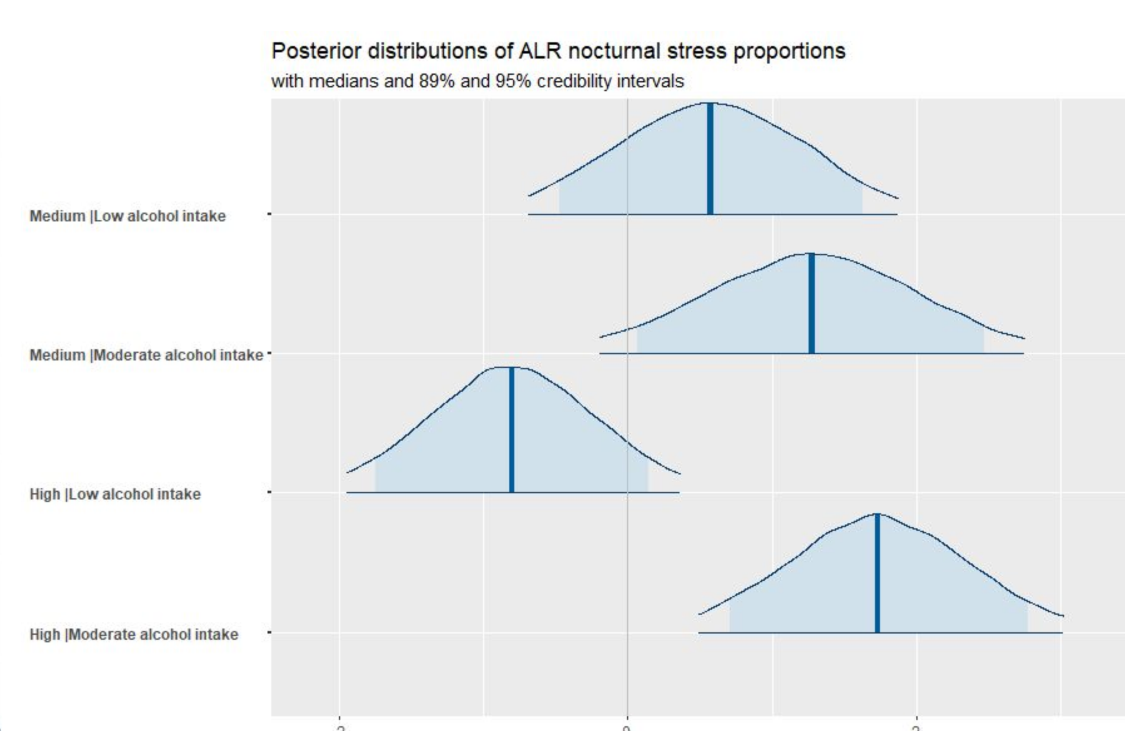
Normally distributed priors for model parameters were used.

## Results

For creating of ALR of sleep stages, proportion of Light sleep was used as a baseline, for Deep, REM and Awake sleep proportions. For creating of ALR of nocturnal stress levels, Resting (0-25) stress was used as a baseline, for Medium (26-50) stress and High (51-100) stress proportions.
Selected effects are shown as median estimates with 89% and 95% credibility intervals, which were estimated by MCMC sampling.




## Conclusions

Despite the smaller sample size, we conclude that smartwatches are a promising tool for monitoring individual sleep recovery abilities. Monitoring the patterns of daily life using a questionnaires provides valuable information that can quantify the impact of different factors on an individual's recovery ability. Furthermore, modelling approach using Bayesian mixed effect model takes into account the heterogeneity of individuals and also allows efficient parameter estimation with smaller data sizes. The acquired knowledge will be used in follow-up research to develop a personalized system for burnout prevention.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