

The mixture hidden Markov model for the analysis of Internet usage and well-being among adolescents



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Introduction

We studied **Internet usage and well-being** among Swiss 8th graders. The adolescents were observed five times in six-month intervals from spring 2012 to spring 2014.

Mixture hidden Markov modelling was used for the **joint analysis of five parallel sequences** to capture longitudinal patterns in Internet usage, Internet addiction, emotional well-being, sleep problems, and academic performance. The aim was to find latent groups with different patterns, to model longitudinal dynamics within groups, and to explain group memberships with background information.

Data

- 364 eight graders (only 51% observed for each wave of the study)
- Longitudinal variables, answers categorized in three classes
 - **Internet usage** (Internet): Time spent on the Internet during weekdays
 - * <1 hour (less than 1 hour/day), 1–3 hours (less than 3 hours/day), 3+ hours (three hours/day or more)
 - **Internet addiction** (Addiction): Internet Addiction Test score
 - * Low (scores 0–30), Average (31–49), High (50–100)
 - **Emotional well-being** (Well-being): WHO emotional well-being index (3rd wave missing)
 - * Normal (scores 51–100), Low mood (30–50), Depression (0–29)
 - **Sleep problems** (Sleep)
 - * Rarely (less than monthly), Regularly (1–4 times/month), Almost daily
 - **Academic performance** (Academic) (4th wave missing)
 - * Above average, Average, Below average
- Four background variables (measured at the 1st wave)
 - **Gender**: Female (234 adolescents), Male (130)
 - **SES** (socio-economic status of the family): Above average (128), Average or below (236)
 - **Residence**: Town (157), Other (rural area or mountain) (207)
 - **Parents**: Parents together (273), Other (91)

Mixture hidden Markov model

- Here for data with multiple individuals with multiple parallel sequences
- Combination of the latent class model and the hidden (latent) Markov model
 - Longitudinal dynamics within each group described by a hidden Markov model
- Unobserved sequence of hidden states for each individual
 - Markov chain: the probability of transitioning to the next hidden state depends on the current hidden state only
- Hidden states generate observations with varying probabilities
- Covariates affect group membership probabilities

Modelling procedure

1. Estimate latent class models with 3–10 classes
 - Set a reference class with well-being adolescents
2. Add hidden states within latent classes (excluding the reference class)
 - Stop when BIC increases
3. Compute the most probable path of hidden states for each individual
 - Determine group memberships

Conclusions

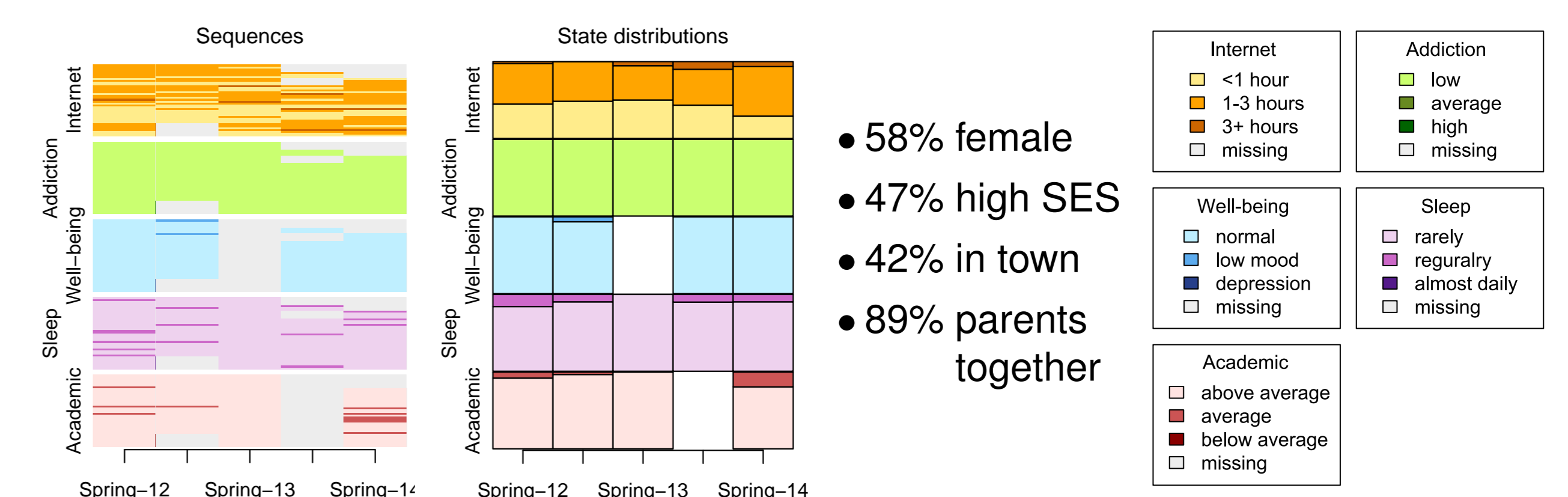
- Fluctuation in observed states, but longitudinal patterns of Internet usage and well-being were relatively static during the 2.5-year follow-up
 - 7 groups: no change in hidden process
 - 1 group: three hidden states (at most one transition per individual)
- Internet addiction was often connected to problems in other life domains, especially sleep problems
- Three covariates explained some differences in cluster memberships
 - Gender, SES, Parents

Results

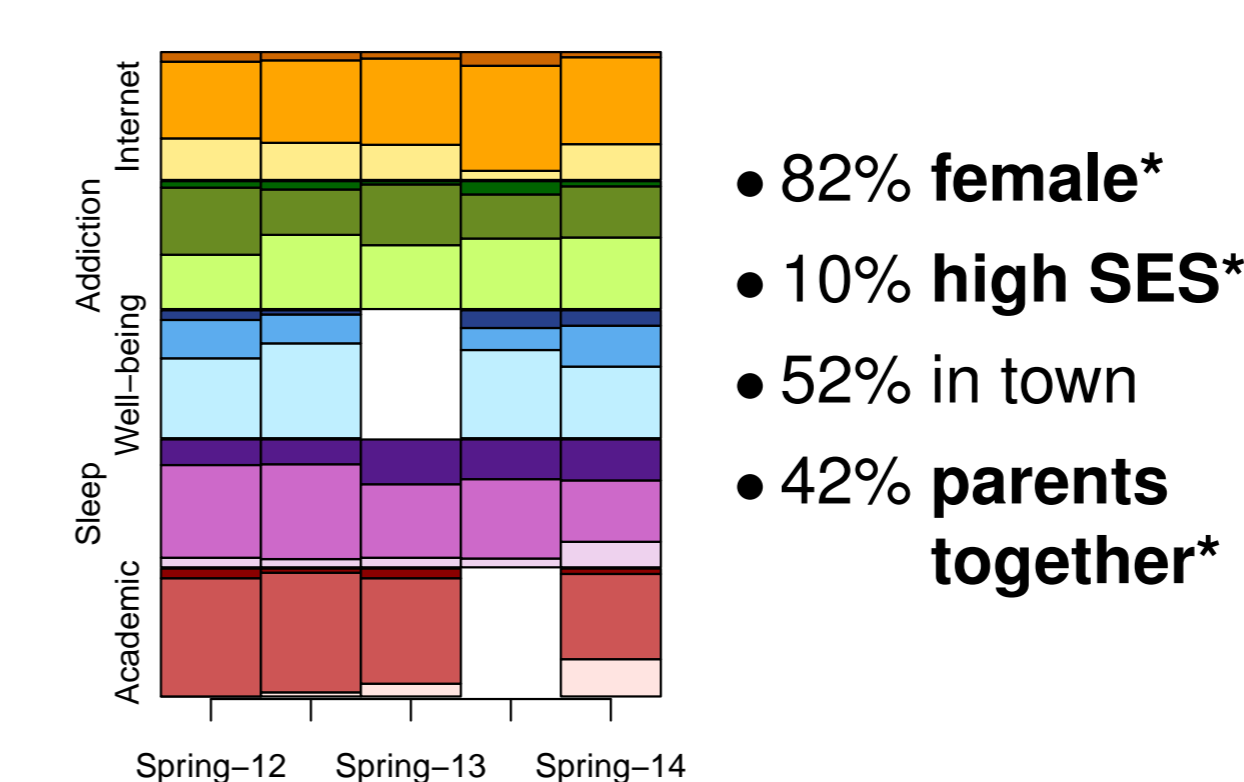
Mixture hidden Markov model with eight groups: A reference group, six other latent classes, and a hidden Markov model with three hidden states.

Figures show observed sequences for the reference group and the multistate group, and observed state distributions in time for latent classes (showing the time-invariant nature of the groups). For multistate group, observation probabilities for different states are shown together with observed and most probable hidden state sequences.

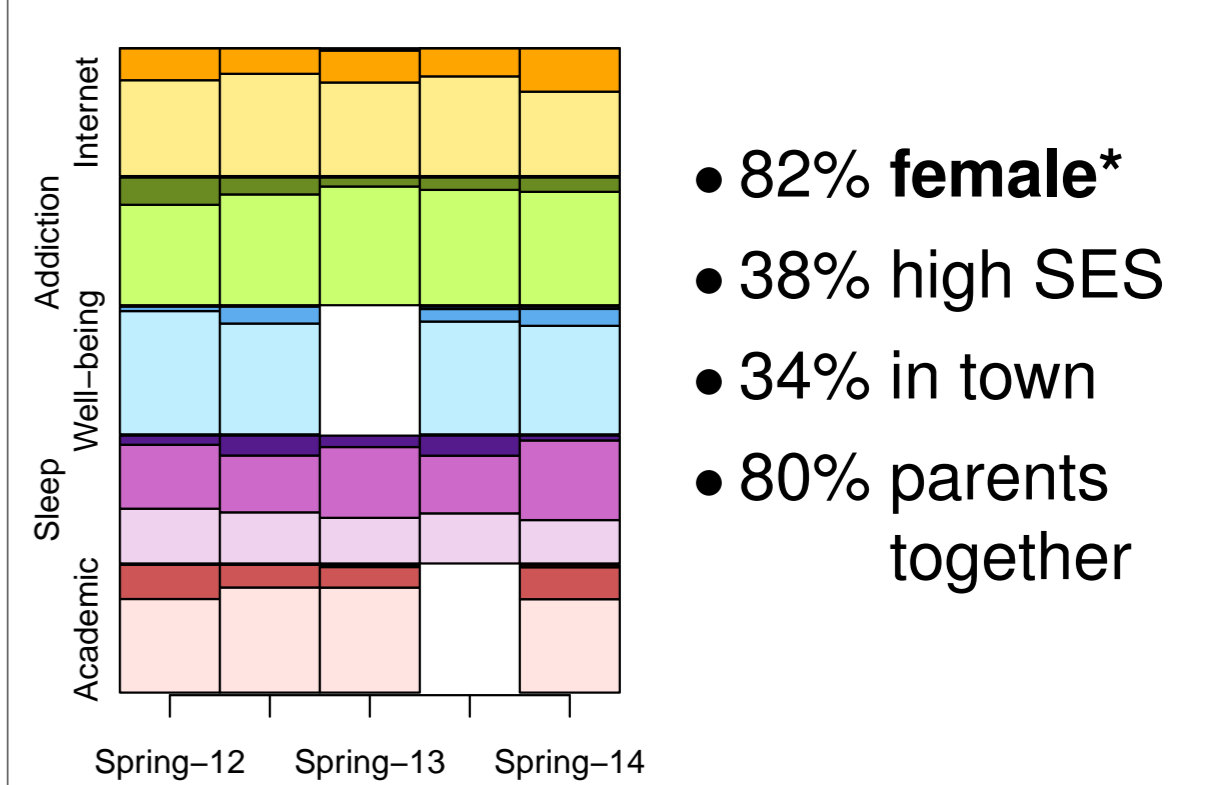
Reference group: Thriving average (Internet) users, n = 38



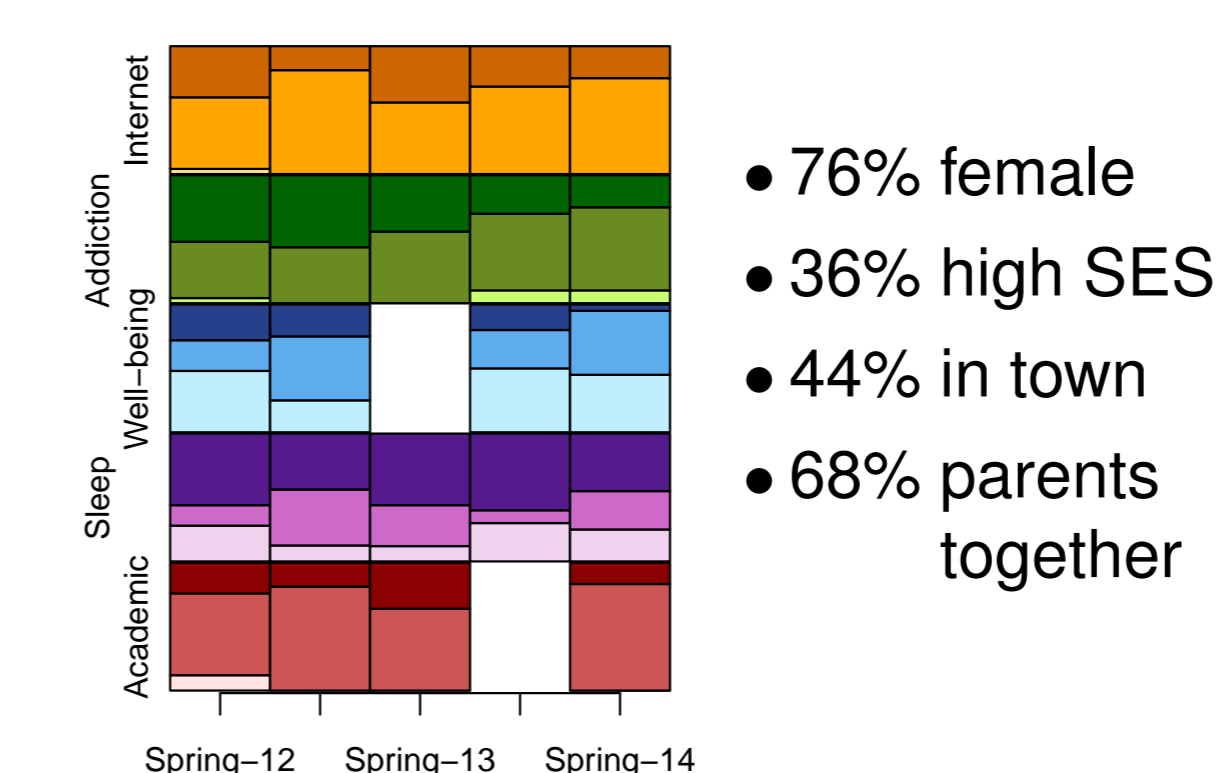
Addicted average students with sleep problems, n = 40



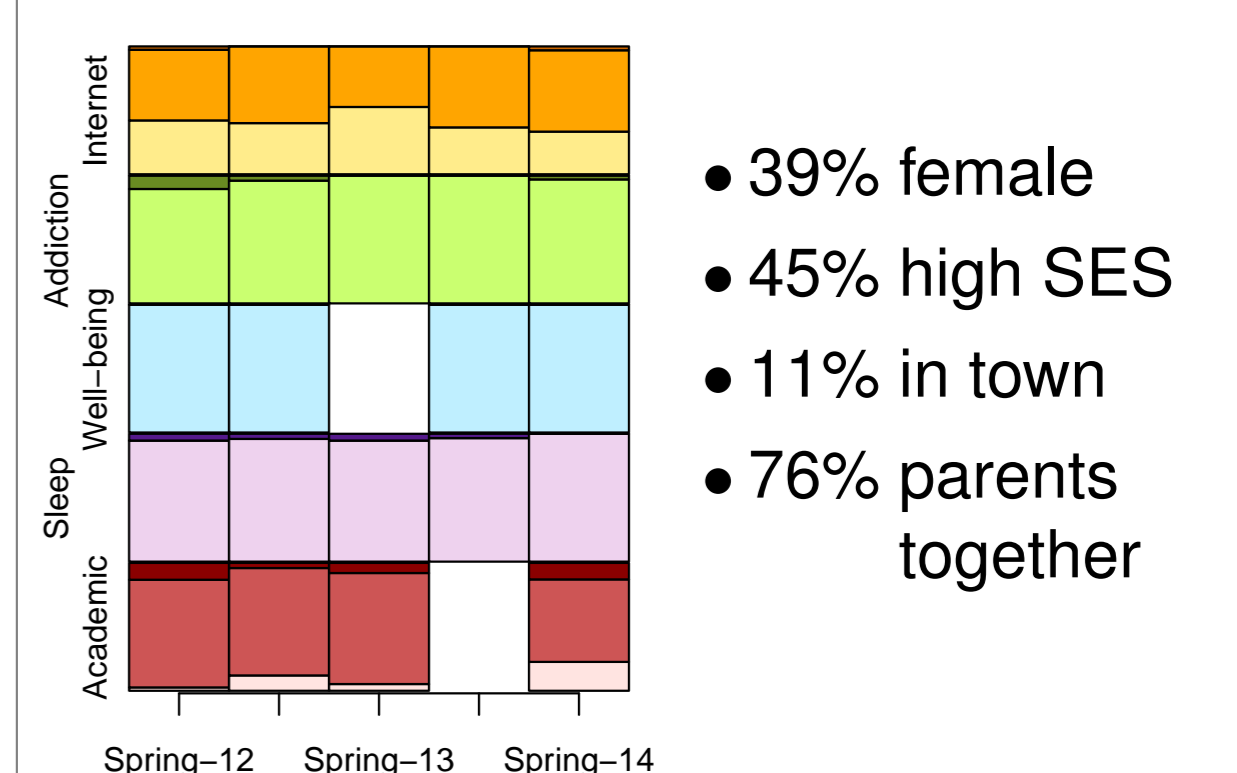
Low users with sleep problems, n = 56



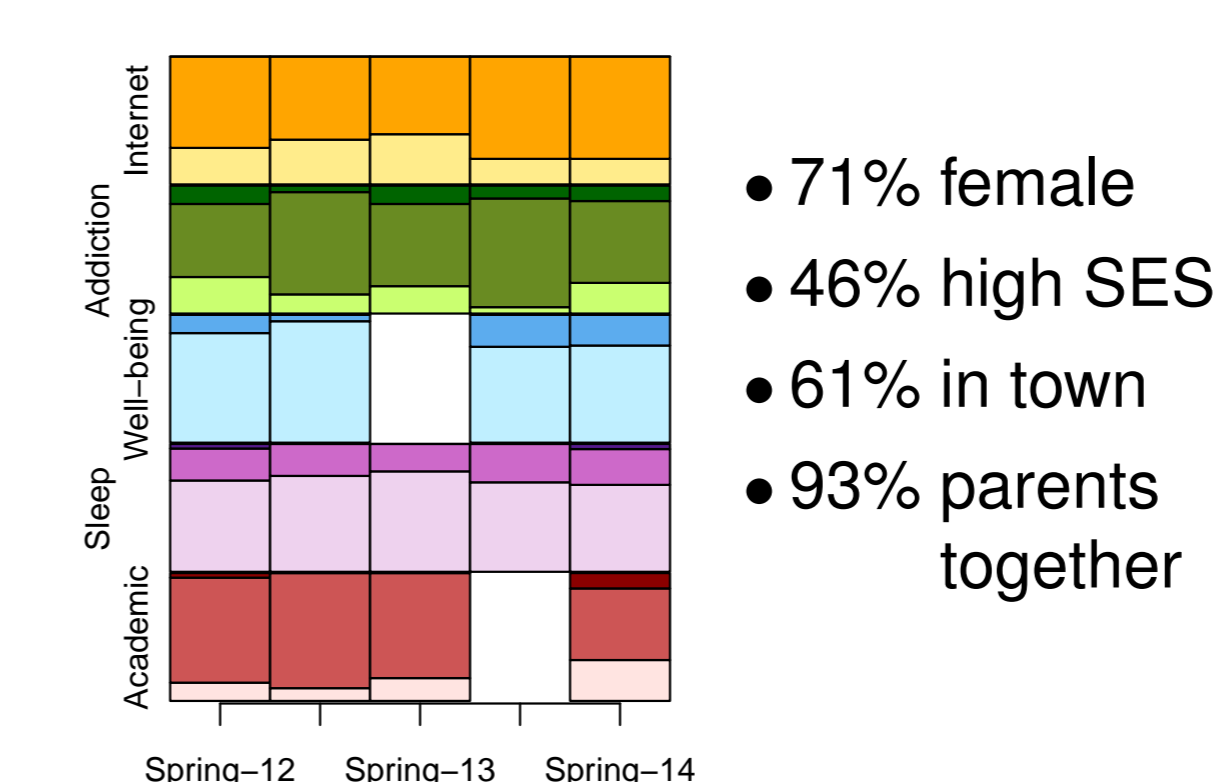
Multiproblematic adolescents, n = 25



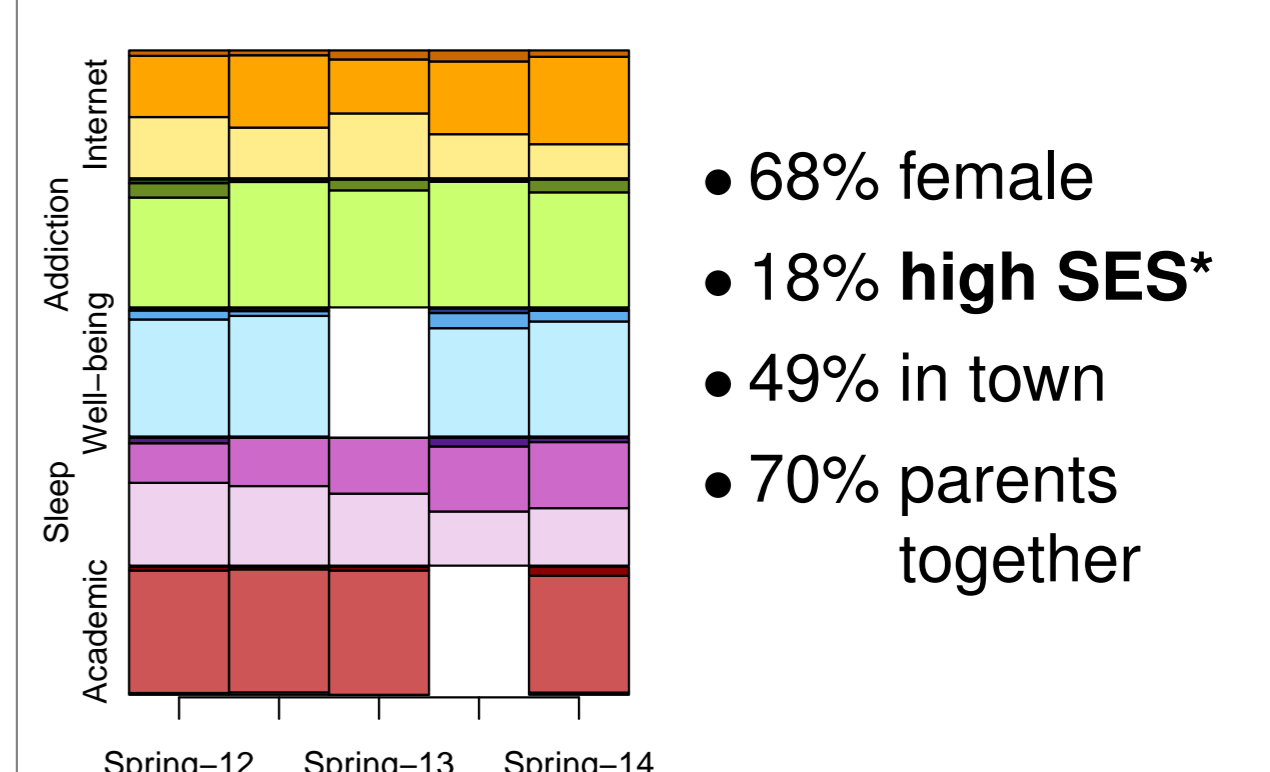
Thriving average students, n = 38



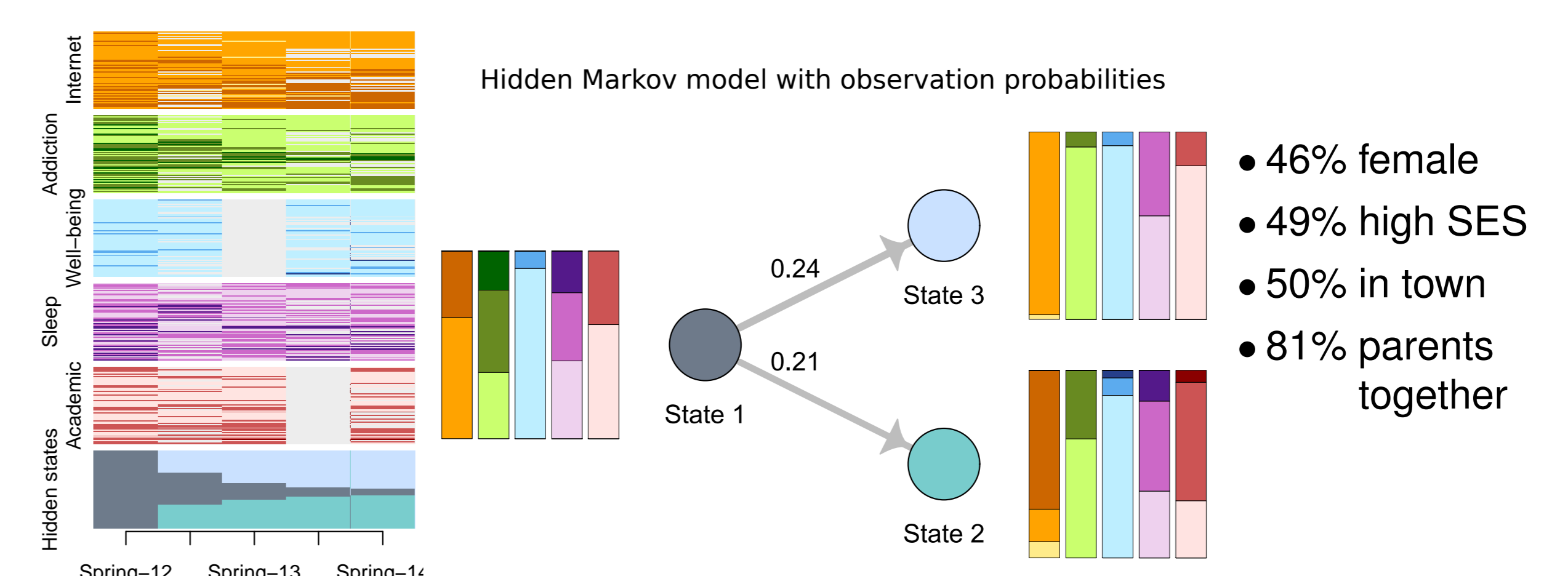
Addicted average students, n = 28



Average students with regular sleep problems, n = 71



Heavy users with changing patterns, n = 68



* Statistically significant difference in proportions compared to the reference class.

References

Helske S, Helske J (2016). Mixture Hidden Markov Models for Sequence Data: the seqHMM Package in R. Submitted.