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## Background

- Depression affects approximately 350 million people worldwide [2], leading to suicide in the worst of cases.
- Depression is characterised by a set of symptoms which could be affected by social networks.
- We explore the effect of social networks on the improving or worsening of depressive symptoms in individuals.

## Method (i): Data

- We used data from the National Longitudinal Study of Adolescent Health (Add Health), which explores health behaviours of United States adolescents, from two different time points: 1994-95 and 1996 [1]. Respondents could list friends, so a friendship network could be constructed.
- 18 out of 20 questions from the Centre for Epidemiologic Studies Depression (CES-D) scale, a self-assessed questionnaire designed to measure depressive symptoms, were asked to Add Health respondents [3].

## Method (ii): Statistical models

- We split the CES-D scores into 7 component symptoms: anhedonia, poor appetite, poor concentration, dysphoria, helplessness, tiredness, and worthlessness.
- We analysed two models where individuals could either worsen (increase in score) with probability  $p_k$ , improve (decrease in score) with probability  $q_k$ , or not change. Model 1 had possible dependency on the number of worse off (higher scoring) friends  $k$ , and model 2 on the number of better off (lower scoring) friends  $k$ .
- $p_k$  and  $q_k$  had two possible forms. No transmission (independent of  $k$ )

$$p_k = \alpha \quad q_k = \delta$$

and transmission (dependent on  $k$ )

$$p_k = \alpha + \beta \sum_{l=0}^k \binom{10}{l} \gamma^l (1-\gamma)^{10-l} \quad q_k = \delta + \epsilon \sum_{l=0}^k \binom{10}{l} \zeta^l (1-\zeta)^{10-l}$$

- Four possible cases were considered for each model: both  $p_k$  and  $q_k$  having transmission form, both having no transmission form, and the two cases where one has transmission form and the other has no transmission form.
- Maximum likelihood estimates were found of the parameters  $\alpha, \beta, \gamma, \delta, \epsilon,$  and  $\zeta$  for each model for each symptom using numerical optimisation of the multinomial likelihood function

$$\mathcal{L}(\mathbf{x}, \mathbf{y} | \mathbf{p}, \mathbf{q}, \mathbf{N}) = \prod_k \binom{N_k}{x_k, y_k, N_k - x_k - y_k} p_k^{x_k} q_k^{y_k} (1 - p_k - q_k)^{N_k - x_k - y_k}$$

where, for models 1/2,  $N_k$  is the number of individuals with  $k$  higher/lower scoring friends,  $x_k$  is the number of those who worsen, and  $y_k$  is the number of them who improve.

- The preferred case was found by comparing the Akaike information criterion.

## Results - Helplessness

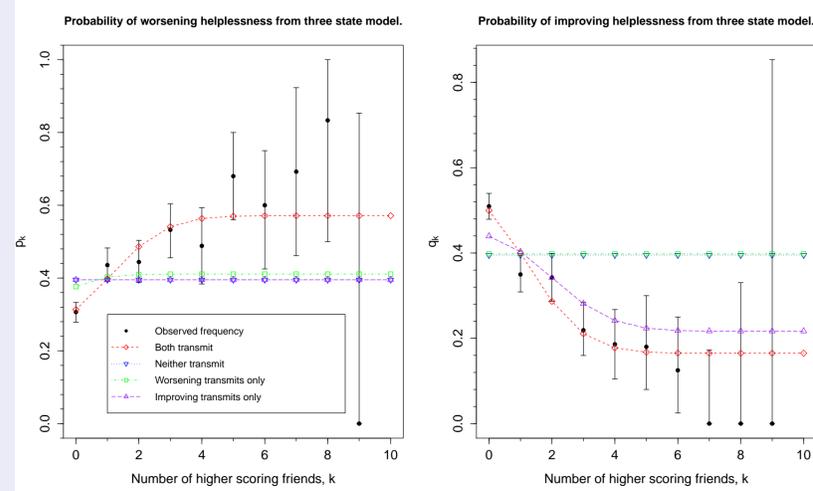


Figure: Model 1. "Both transmit" form is preferred.

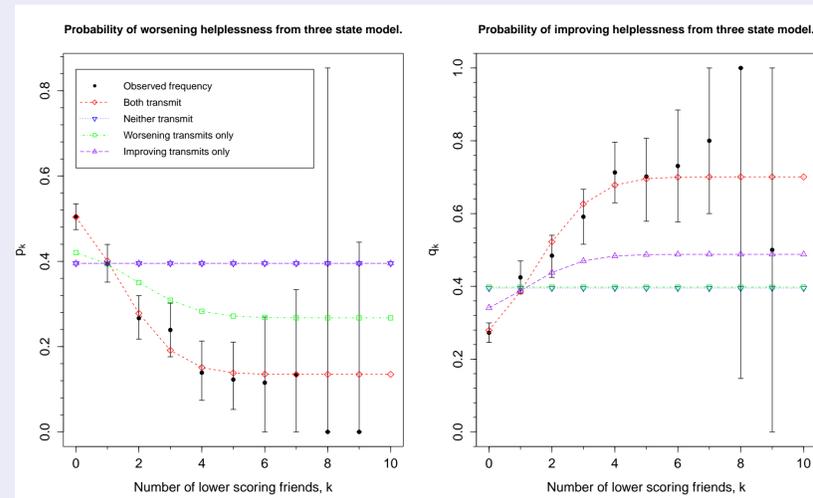


Figure: Model 2. "Both transmit" form is preferred.

## Results - Appetite

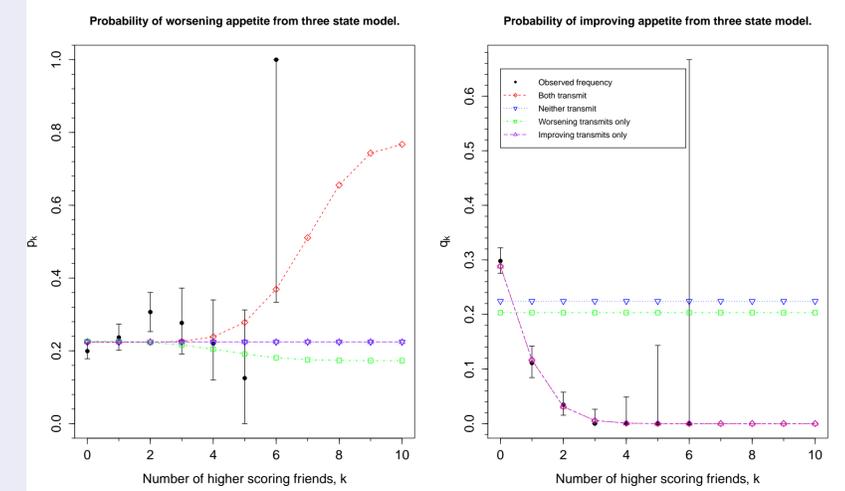


Figure: Model 1. "Improving transmits only" form is preferred.

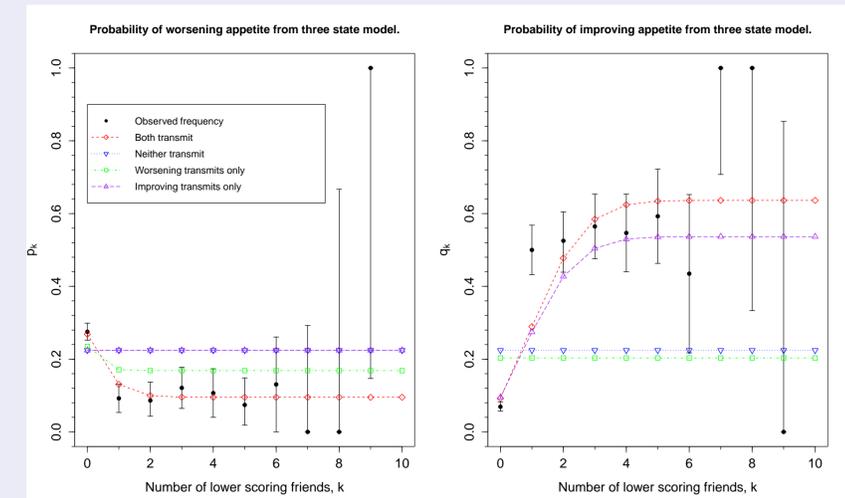


Figure: Model 2. "Both transmit" form is preferred.

## Conclusions

- For most symptoms for both models the case of both  $p_k$  and  $q_k$  having transmission form is preferred. This means that having more worse off friends makes you more likely to get worse, and less likely to get better, and vice versa for better off friends.
- Appetite is the only symptom to differ. For model 1,  $q_k$  has transmission form, and  $p_k$  has no transmission form. This does reflect the data. It could be explained by the lack of variability individuals were allowed for changing their appetite score.
- For further work, firstly some of the symptoms have observed data that, by eye, does not appear to match the preferred model exactly. Models with more complicated shapes could be explored. Secondly, the data could be explored for further evidence of dependency on the friendship network. Thirdly, other risk factors for depression, such as wealth and community support, were covered in the Add Health interviews. Their dependency on the friendship network could also be explored.

## References

- [1] E. Whitsel J. Hussey J. Tabor P. Entzel K. Harris C. Halpern and J. Udry. *The National Longitudinal Study of Adolescent Health: Research Design*. 2009. URL: <http://www.cpc.unc.edu/projects/addhealth/design>.
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- Lenore Sawyer Radloff. "The CES-D scale a self-report depression scale for research in the general population". In: *Applied psychological measurement* 1.3 (1977), pp. 385-401.