



Social contagion over adolescent friendship networks

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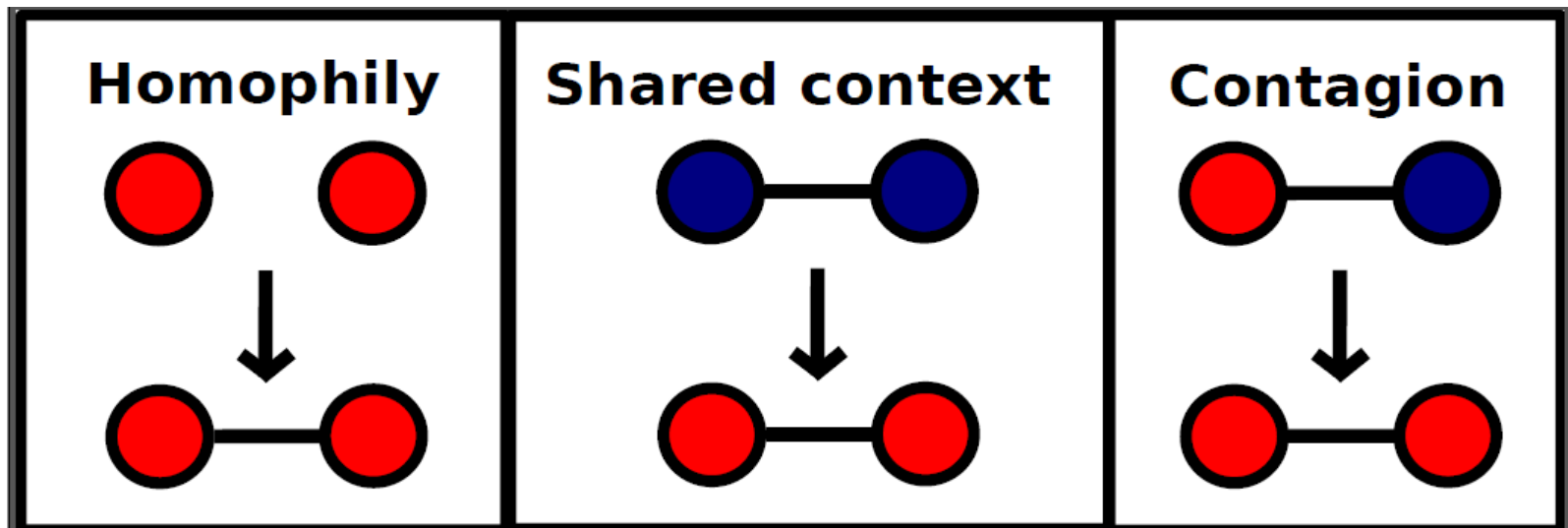
Division of Health Sciences Seminar Series

Outline

- Why are we interested in social contagion?
- The data
- Initial work on modelling mood
- Further work on modelling mood
- Obesity work

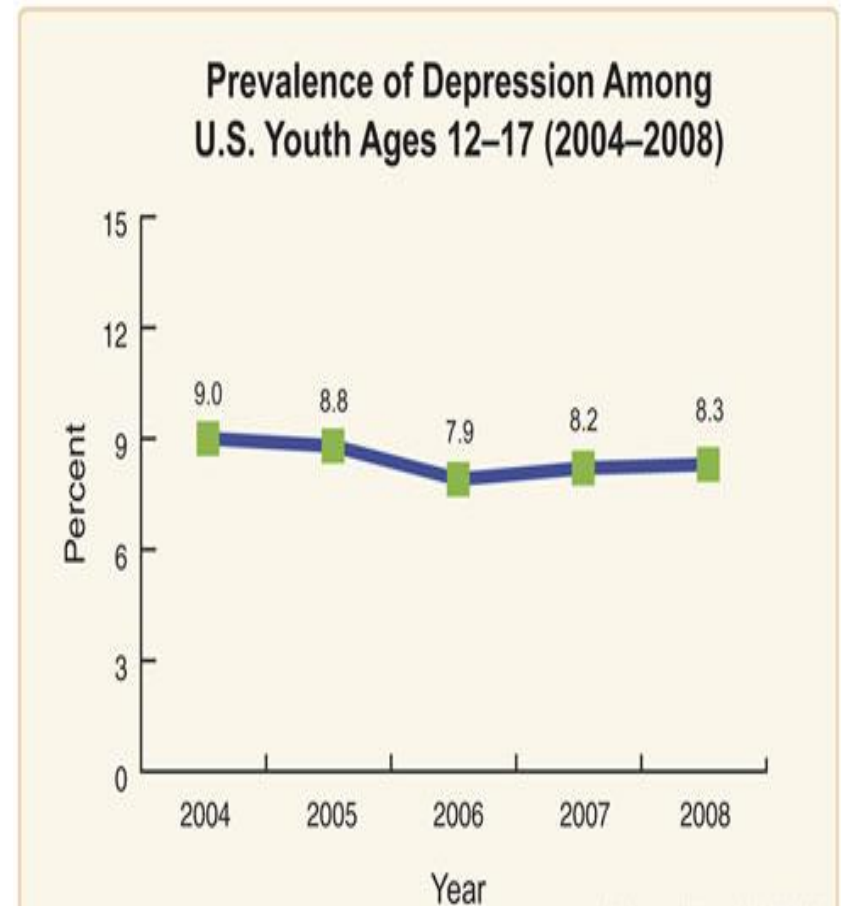
Social contagion theory: examining dynamic social networks and human behavior

Nicholas A. Christakis^{a,b,*†} and James H. Fowler^{c,d}



Understanding the Influence of Social Networks on Emotional State

- The World Health Organisation estimates there are currently more than **350 million people affected by depression**.
- Can the **number and nature of social ties** be used to determine the future emotional state of an individual?



Produced by the Substance Abuse and Mental Health Services Administration.

The Data

The National Longitudinal Study of Adolescent to Adult Health (Add Health)

- Sample of United States adolescents in grades 7 through 12.



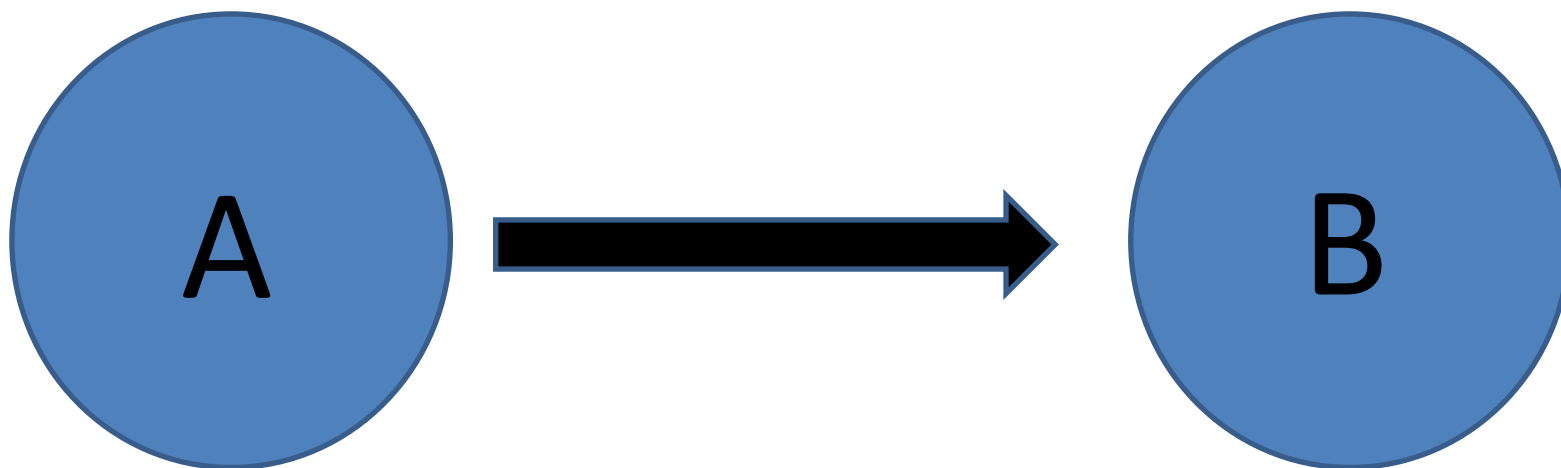
Friendship network

- Respondents were asked to nominate either up to 1 male and 1 female friend, or up to 5 male and 5 female friends.



Centre for Epidemiologic Studies Depression Scale (CES-D)

Friendship Network



The Data

The National Longitudinal Study of Adolescent to Adult Health (Add Health)

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Friendship network

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Centre for Epidemiologic Studies Depression Scale (CES-D)

CES-D Scale

		During the past week:			
		Rarely or none of the time (less than 1 day)	Some or a little of the time (1-2 days)	Occasionally or a moderate amount of time (3-4 days)	Most or all of the time (5-7 days)
1	<i>I was bothered by things that usually don't bother me.</i>	0	1	2	3
2	<i>I did not feel like eating; my appetite was poor.</i>	0	1	2	3
3	<i>I felt that I could not shake off the blues even with help from my family or friends.</i>	0	1	2	3
4	<i>I felt that I was just as good as other people.</i>	3	2	1	0
5	<i>I had trouble keeping my mind on what I was doing.</i>	0	1	2	3

References:

LS Radloff. (1977) The CES-D Scale: a self-report depression scale for research in the general population. *Appl. Psych. Meas.* **1**, 385-401.

CES-D Scale

- Used to create a **binary indicator** of state of mood¹.

$$X_i = \begin{matrix} \text{N} & \text{D} \end{matrix}$$

- According to the score cut-off associated with a clinical diagnosis of depression.

References:

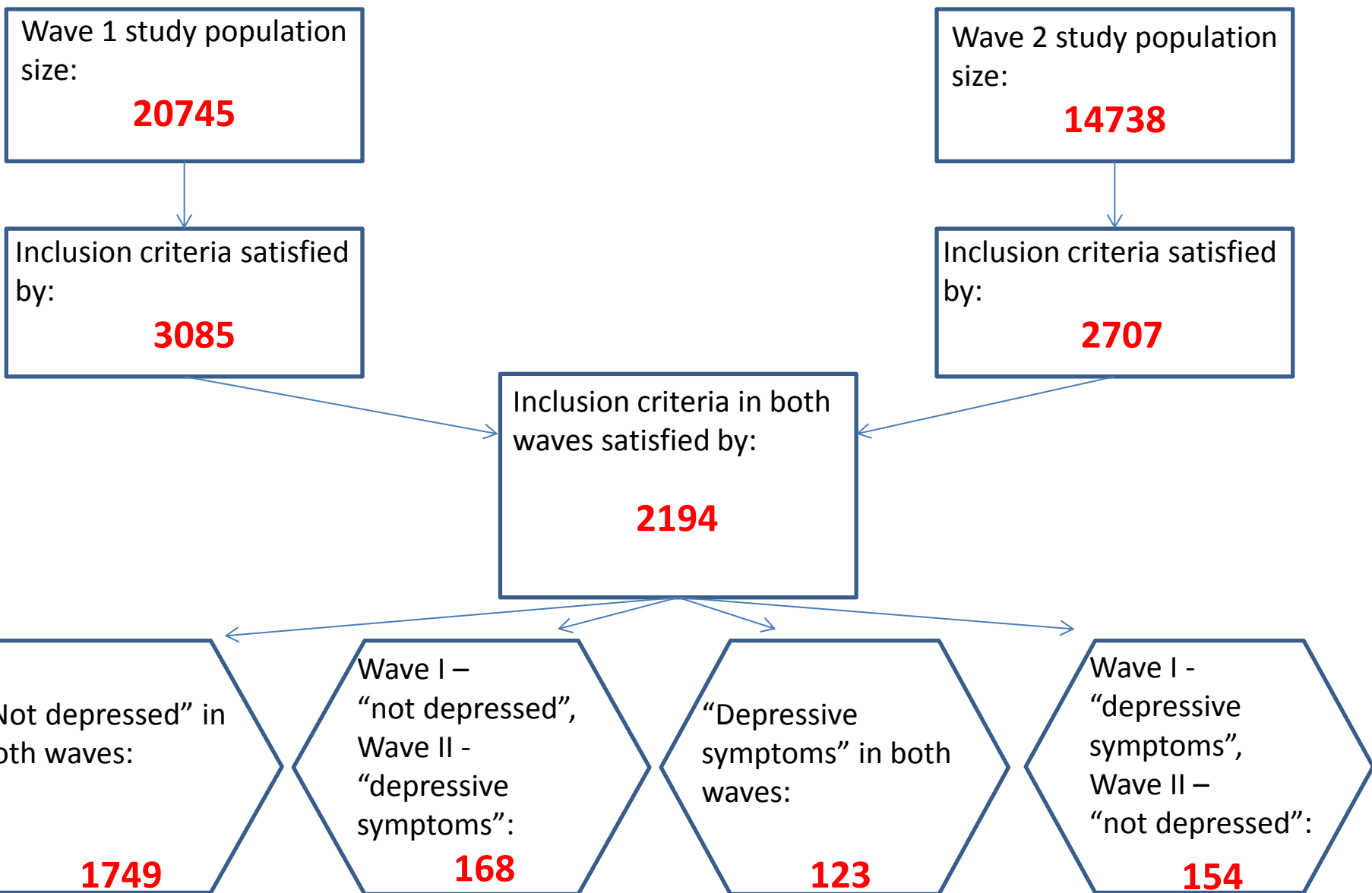
¹RE Roberts, PM Lewinsohn, JR Seeley. (1991) Screening for adolescent depression: A comparison of depression scales. *J. Am. Acad. Child Psy.* **30**, 58-66.

Inclusion Criteria

For a respondent to be included in our study, for both wave 1 and wave 2 they had to:

- be from a saturated school,
- be allowed to list up to 5 male and 5 female friends,
- provide answers to all the CES-D scale related questions.

Wave 1 and 2 Sampling Flow Chart



Proposed Models

$$p = \Pr[X_i(t + 1) = D | X_i(t) = N]$$

Developing Depressive Symptoms

Initial State

Final State

(1)

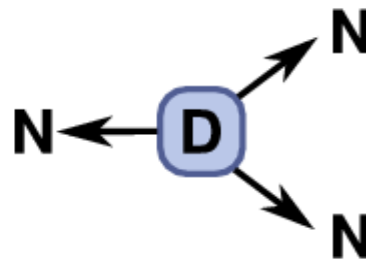
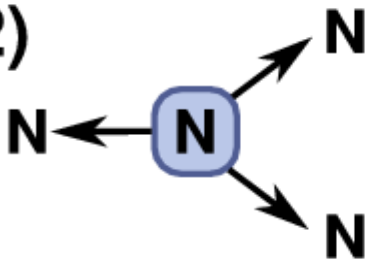
N



D

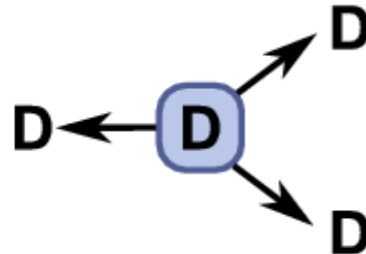
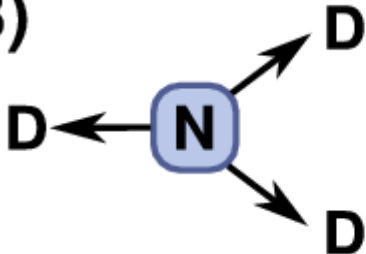
No transmission

(2)



N transmits

(3)



D transmits

Proposed Models

$$q = \Pr[X_i(t + 1) = N | X_i(t) = D]$$

Initial State

Final State

Recovery from Depressive Symptoms

(4)

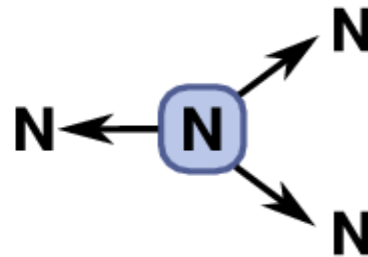
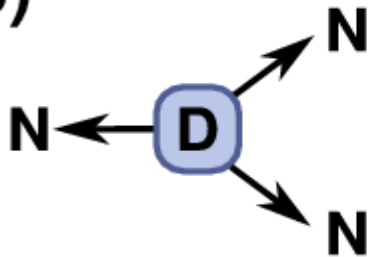
D



N

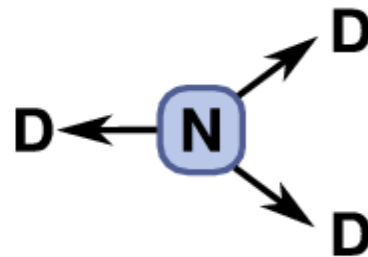
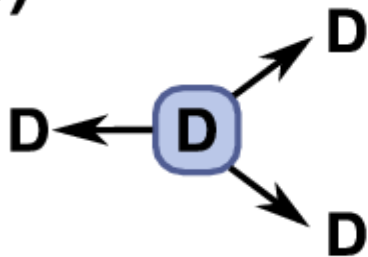
No transmission

(5)



N transmits

(6)



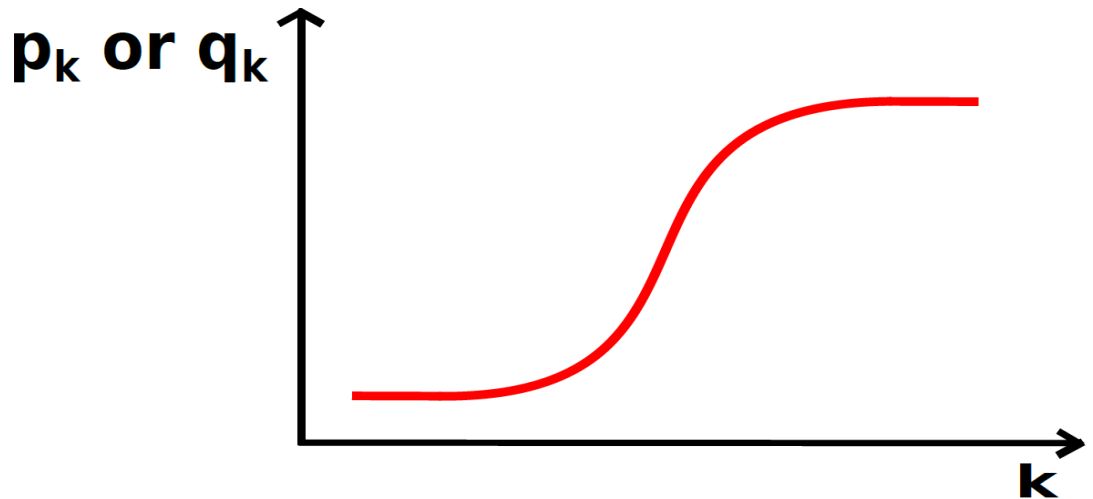
D transmits

Proposed Models

No transmission:



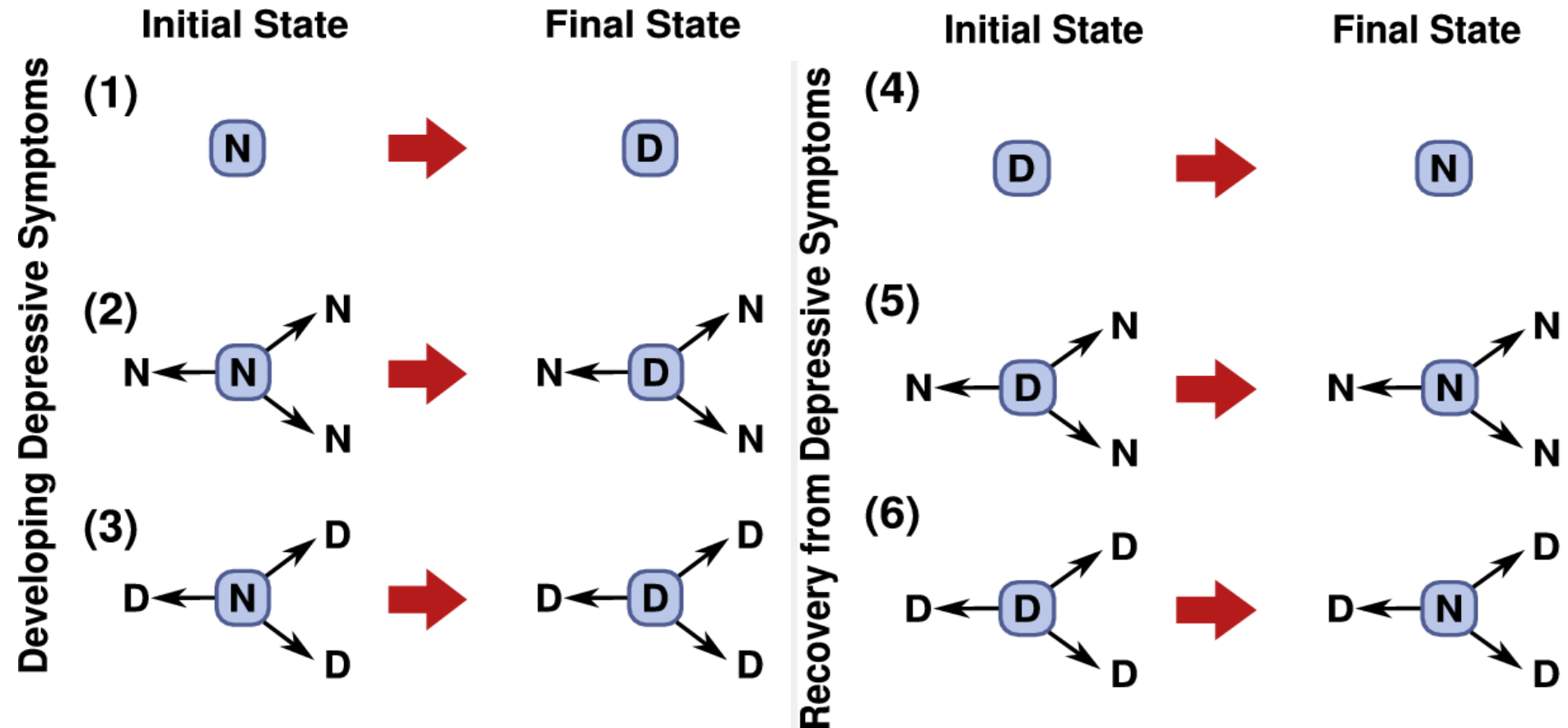
N transmits/
D transmits:



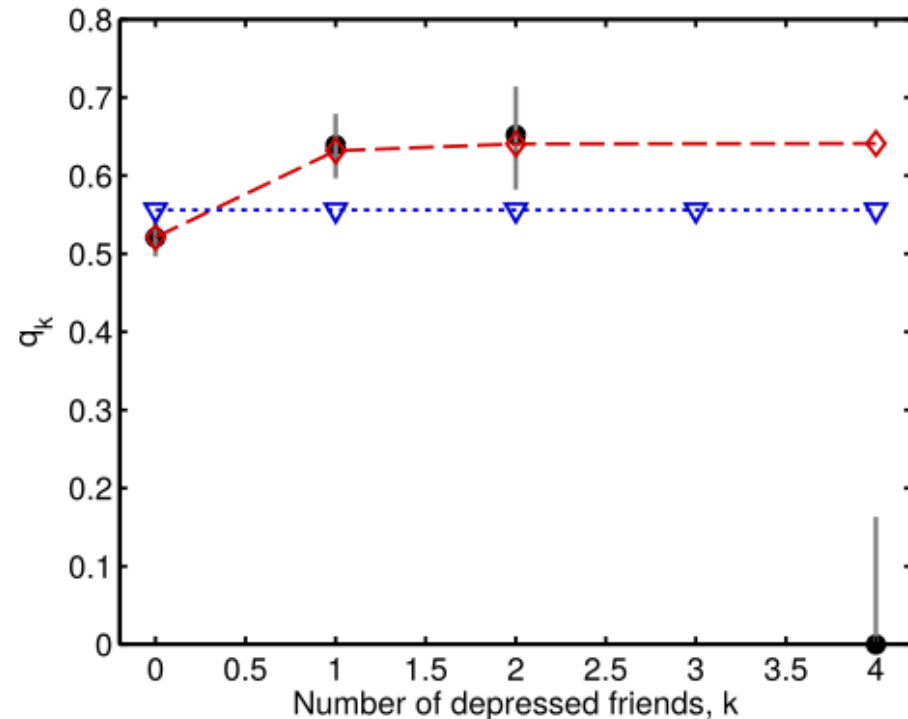
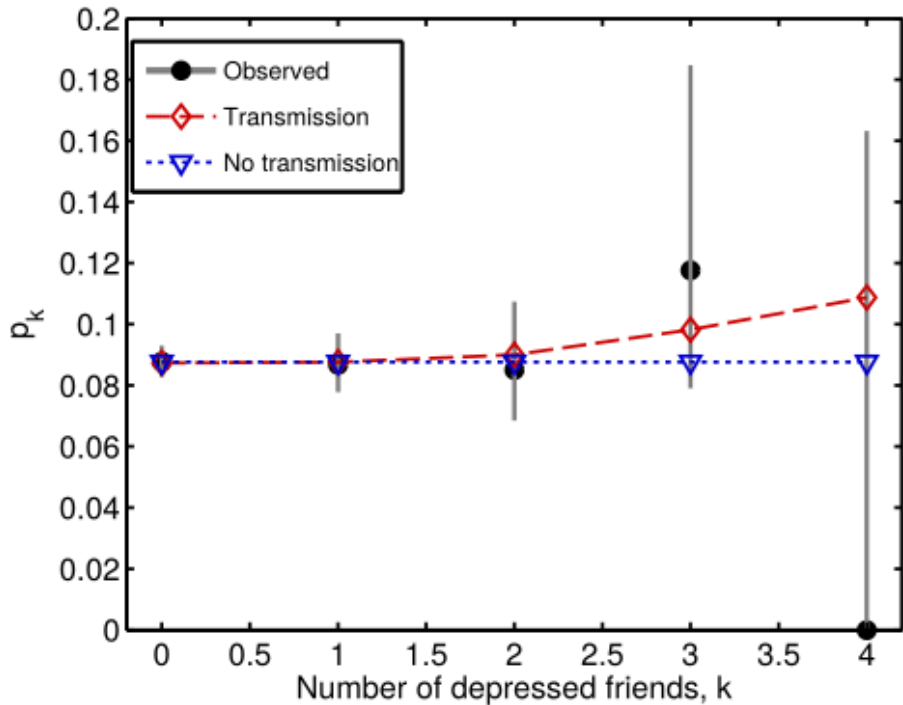
- Competing models assessed using standard statistical methods.

Avoiding confounding

- We fit to the probability of moving to a final state given an initial state.
- Homophily cannot confound the results.

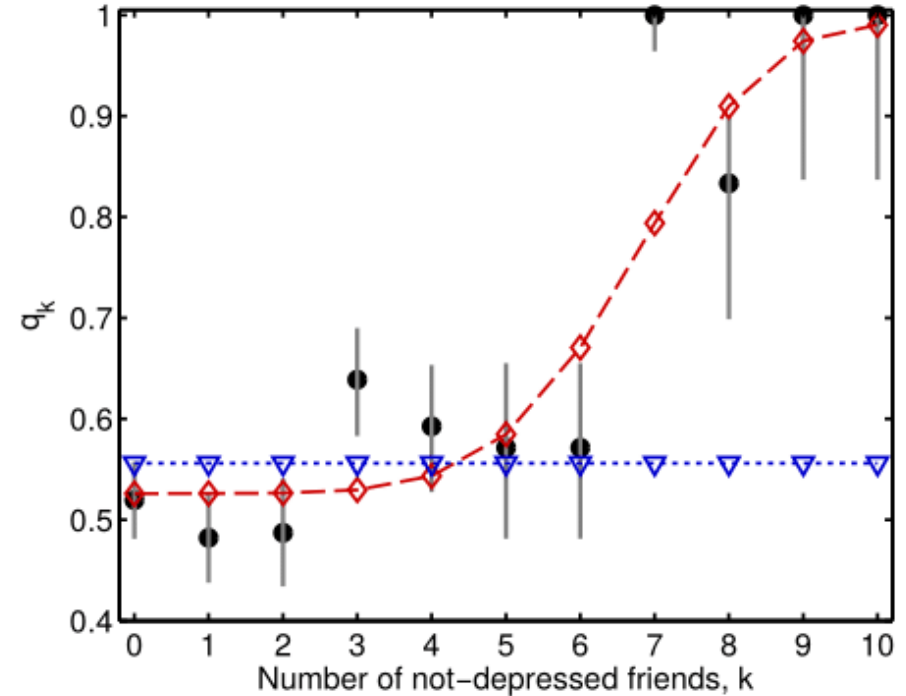
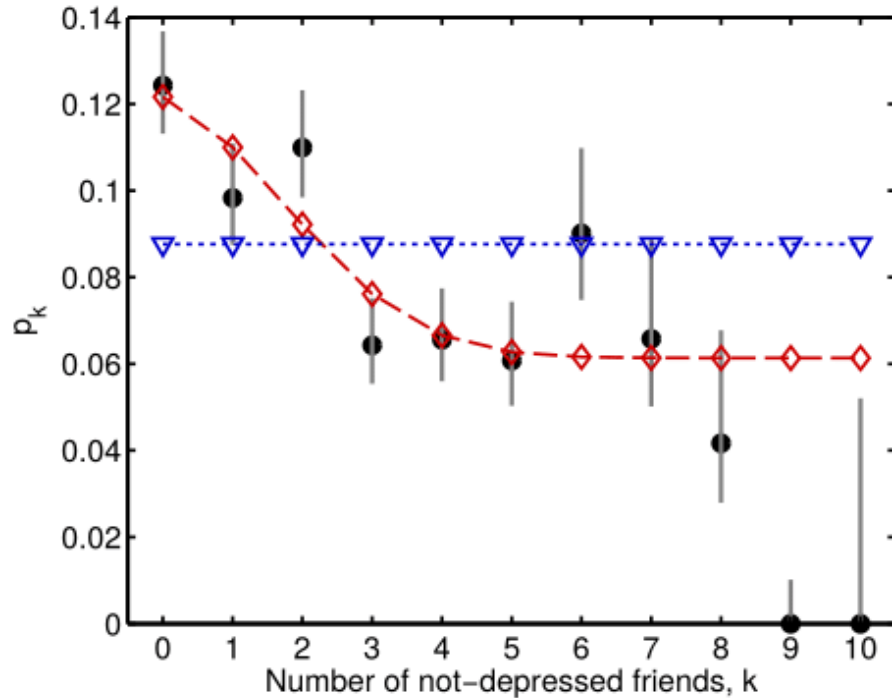


Model Fitting Results – Depressed Friends



➤ D transmits model **not preferred** to no transmission.

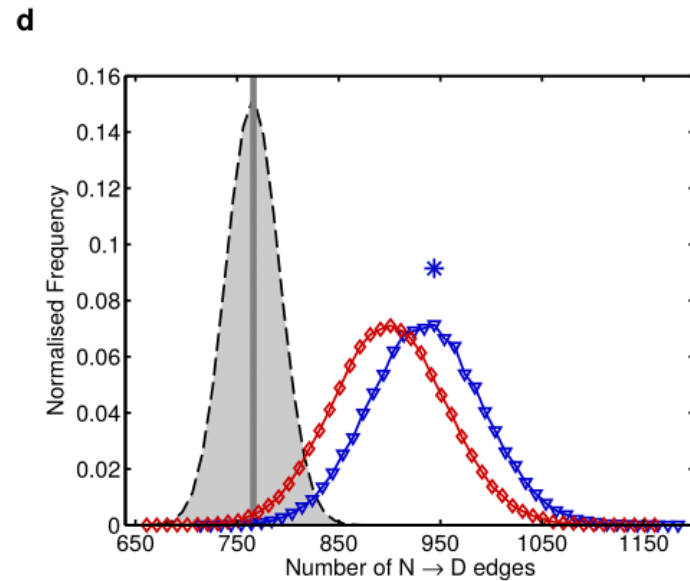
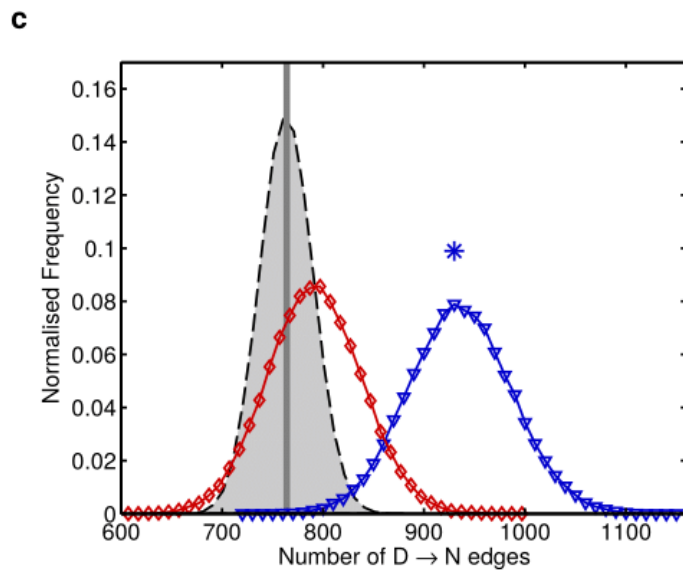
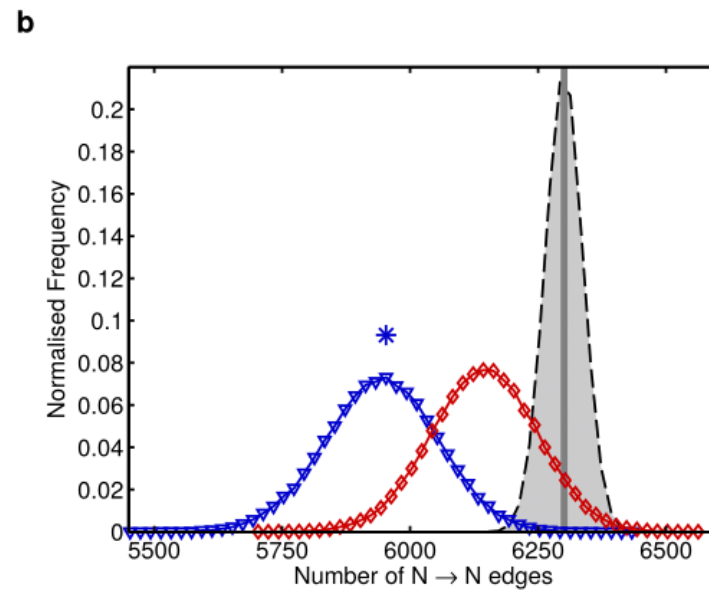
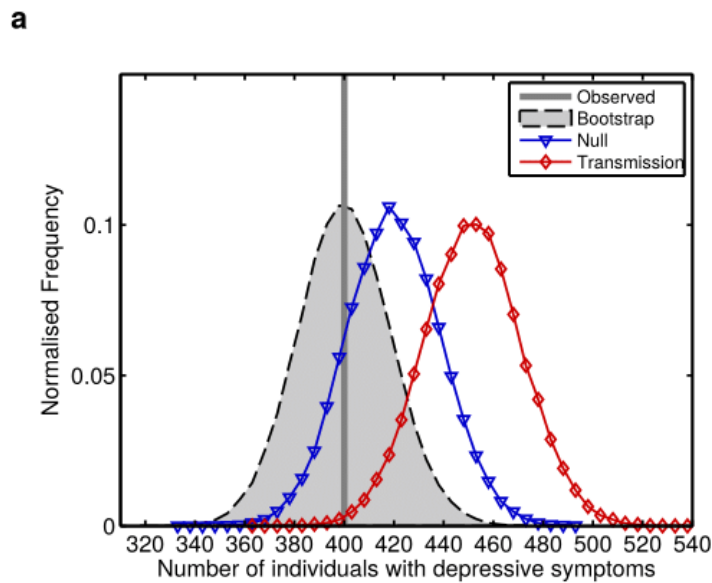
Model Fitting Results – Not Depressed Friends



➤ N transmits model **preferred** to no transmission.

Model goodness-of-fit tests

- Simulated our fitted no transmission model and N transmits model
- Compared simulated static network summary statistics to observed data
- Analysed residual errors



➤ **Significant differences** between the no transmission model and the data.

Summary of findings

- For predicting the individuals most at risk of undergoing a change in emotional state:
 - The number of depressed friends has no causal effect on the emotional state of the individual.
 - Spread of healthy mood can be captured using a non-linear complex contagion model.

Limitations

- Method of classifying emotional state
- Increase or decrease of CES-D raw score based on CES-D raw score of named friends not studied.
- Missing data

$$X_i = \boxed{N} \boxed{D}$$

$$p = \Pr[X_i(t+1) = D | X_i(t) = N]$$

$$q = \Pr[X_i(t+1) = N | X_i(t) = D]$$



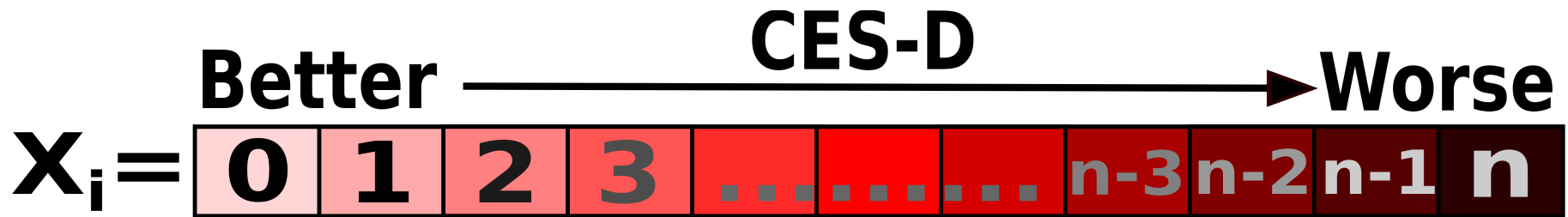
$$p = \Pr[X_i(t+1) > X_i(t)]$$

$$q = \Pr[X_i(t+1) < X_i(t)]$$

$$X_i = \boxed{ND}$$

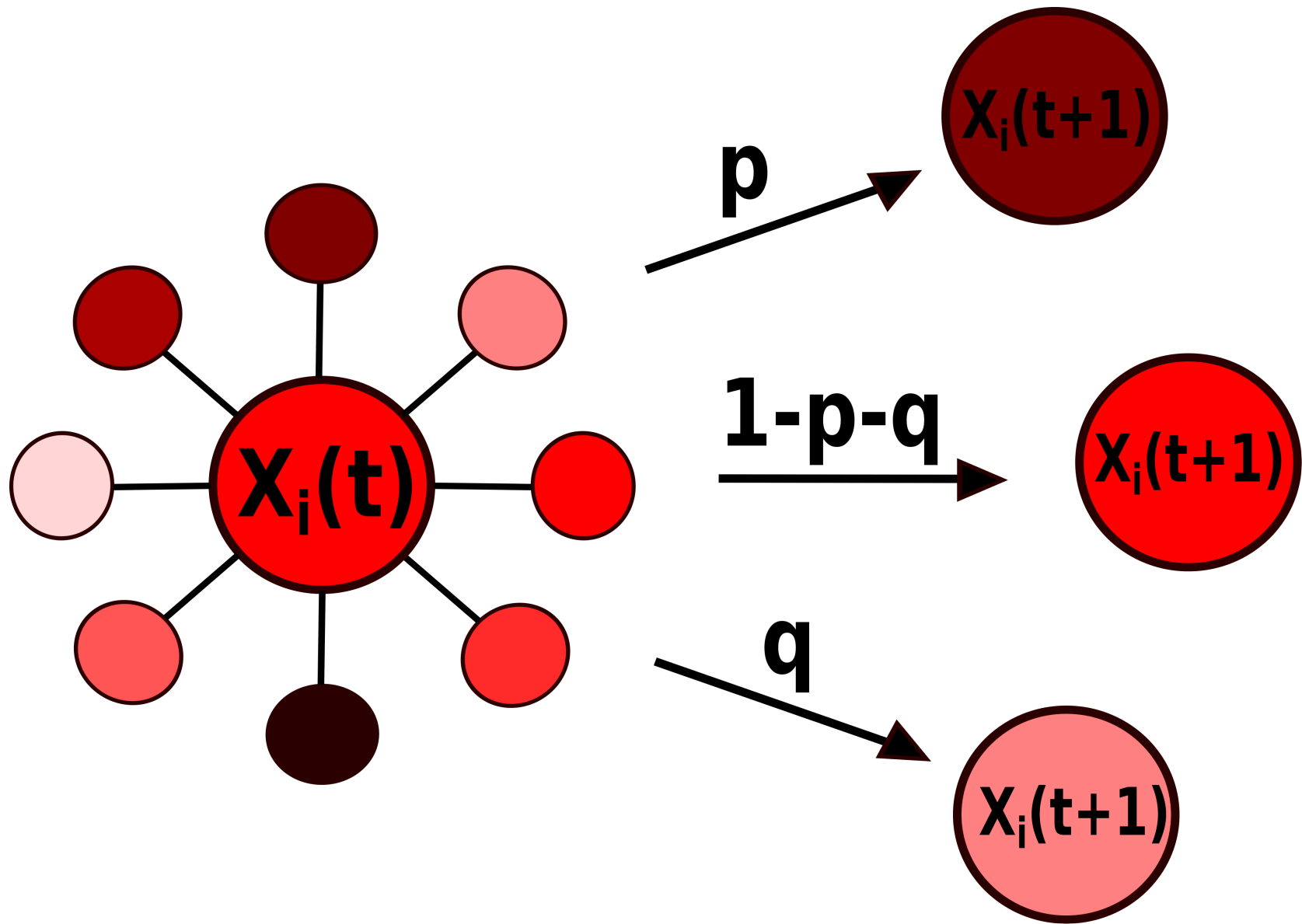
$$p = \Pr[X_i(t+1) = D | X_i(t) = N]$$

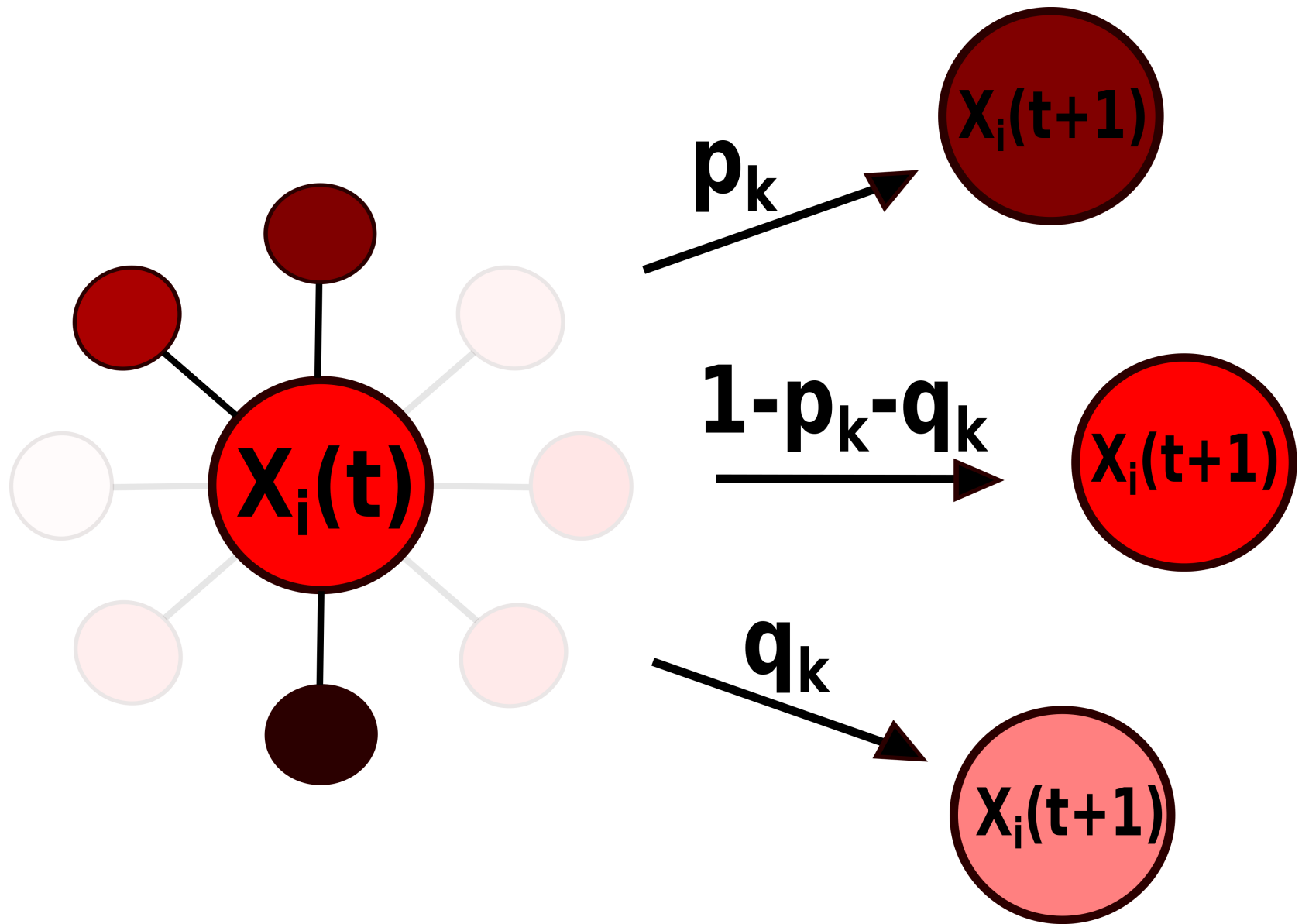
$$q = \Pr[X_i(t+1) = N | X_i(t) = D]$$



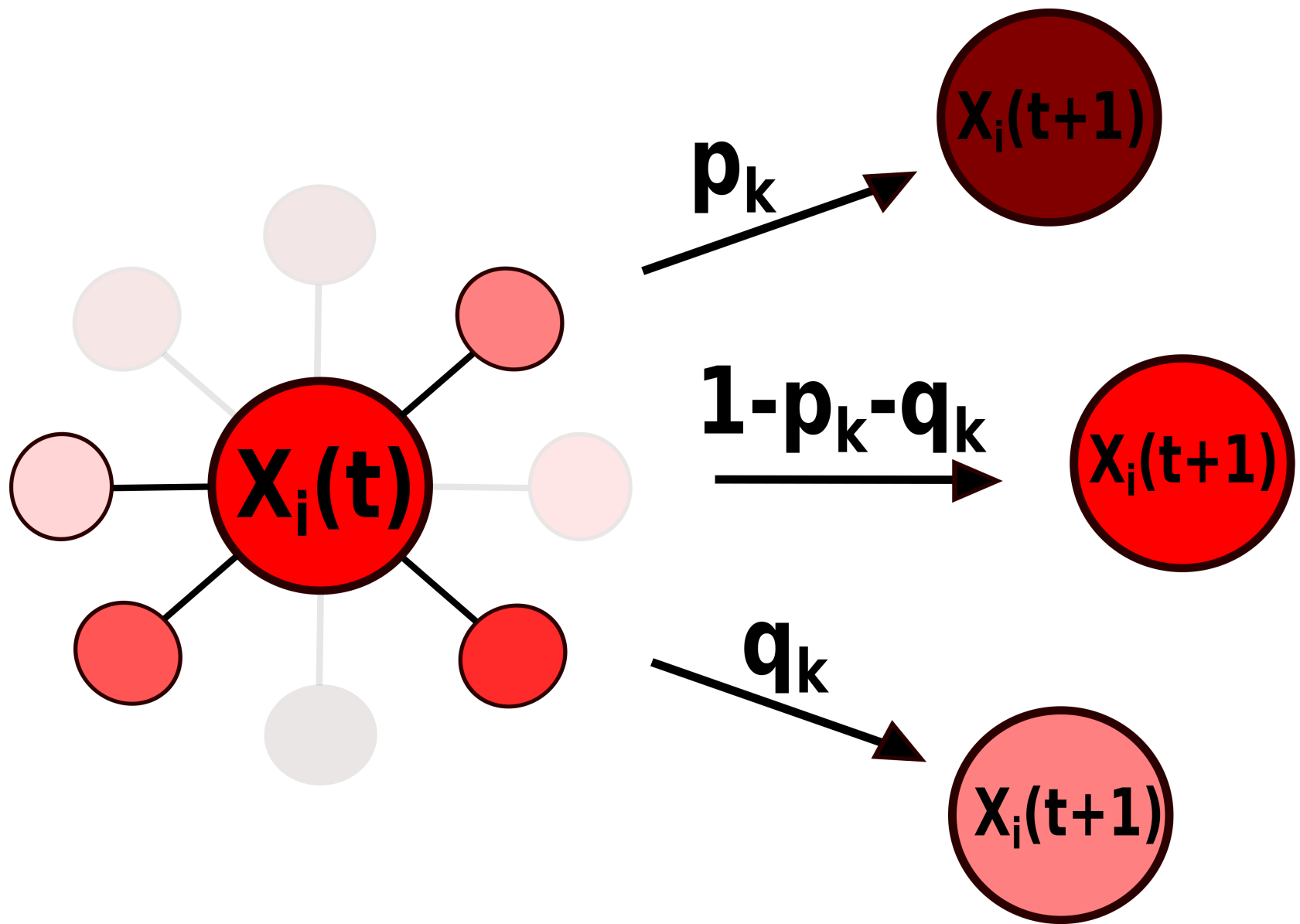
$$p = \Pr[X_i(t+1) > X_i(t)]$$

$$q = \Pr[X_i(t+1) < X_i(t)]$$



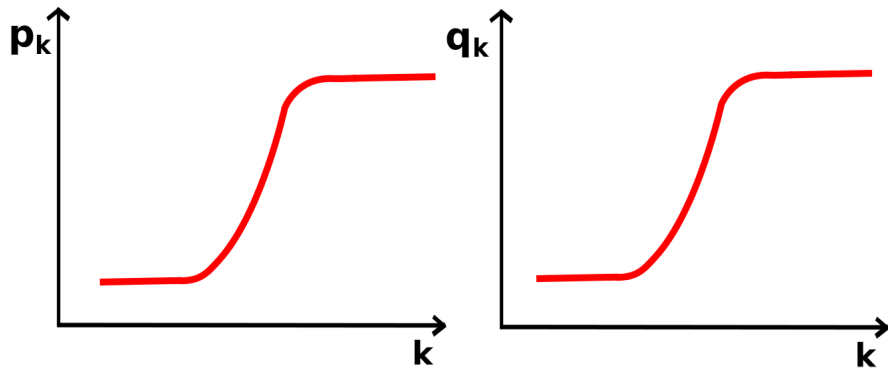


k = Number higher scoring friends

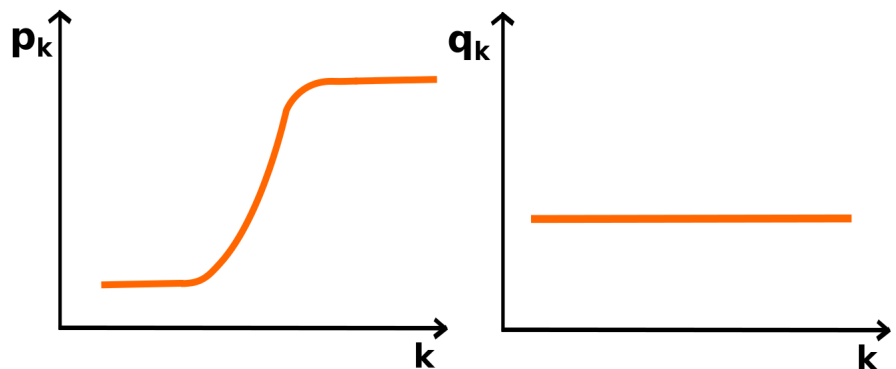
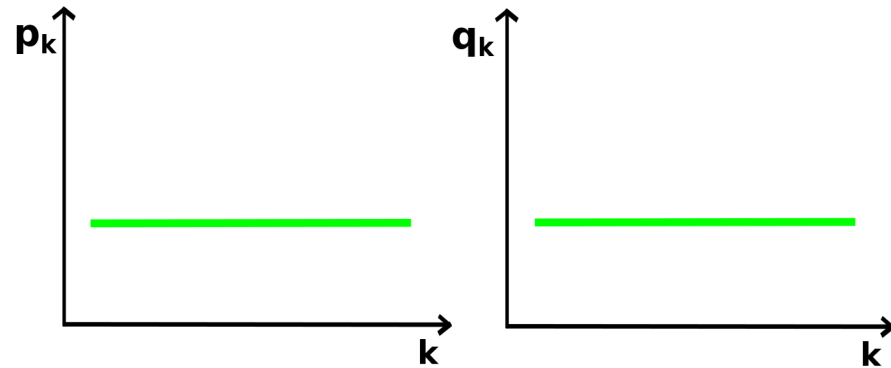


k = Number lower scoring friends

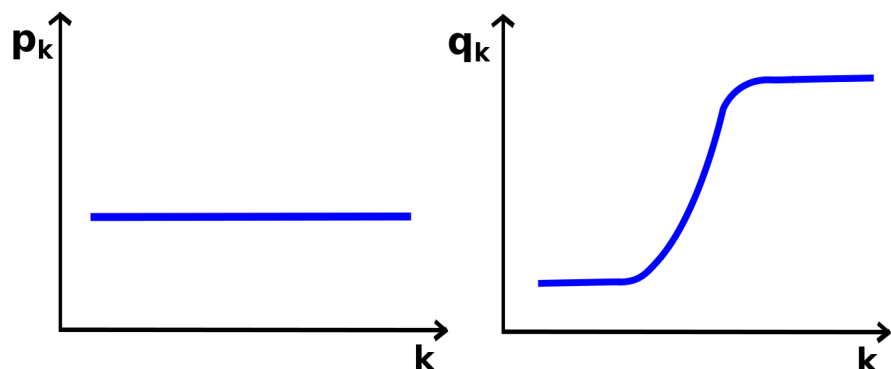
Both transmit



Neither transmit



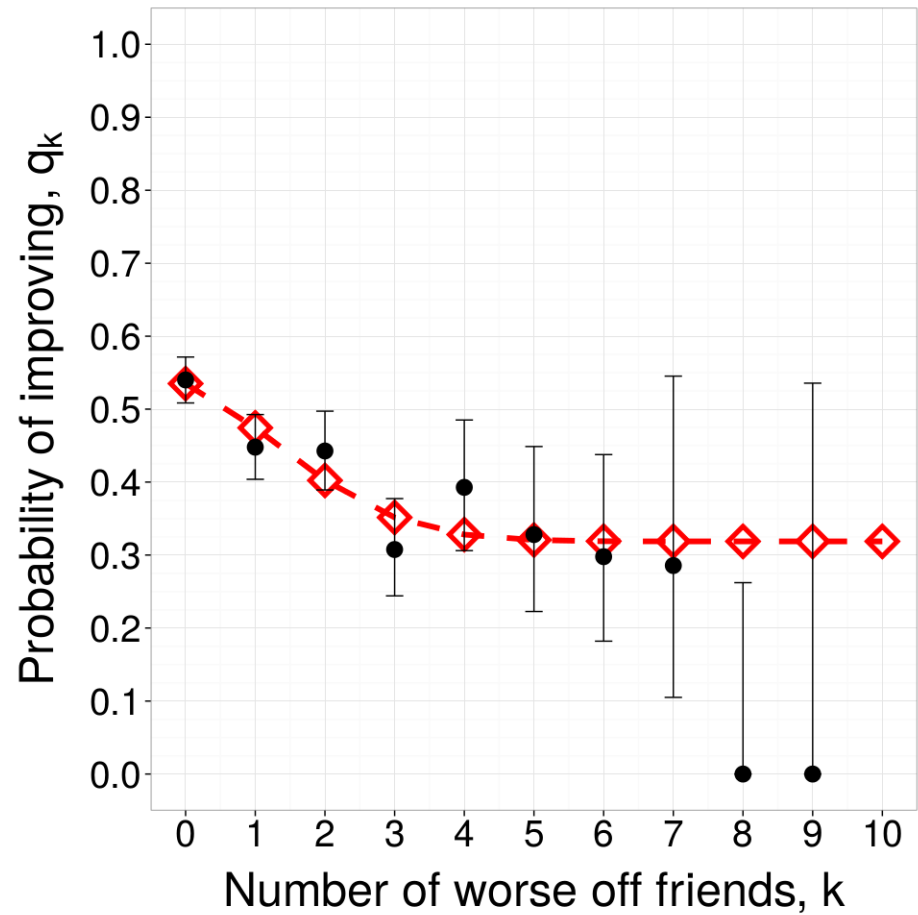
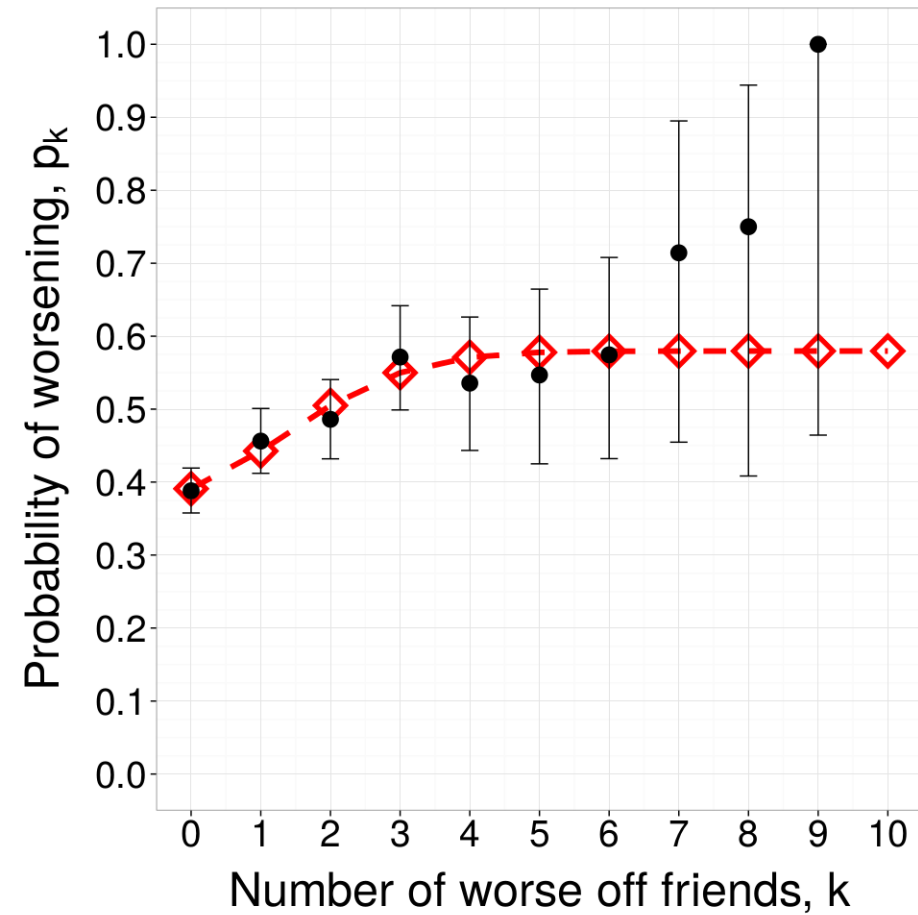
Worsening transmits



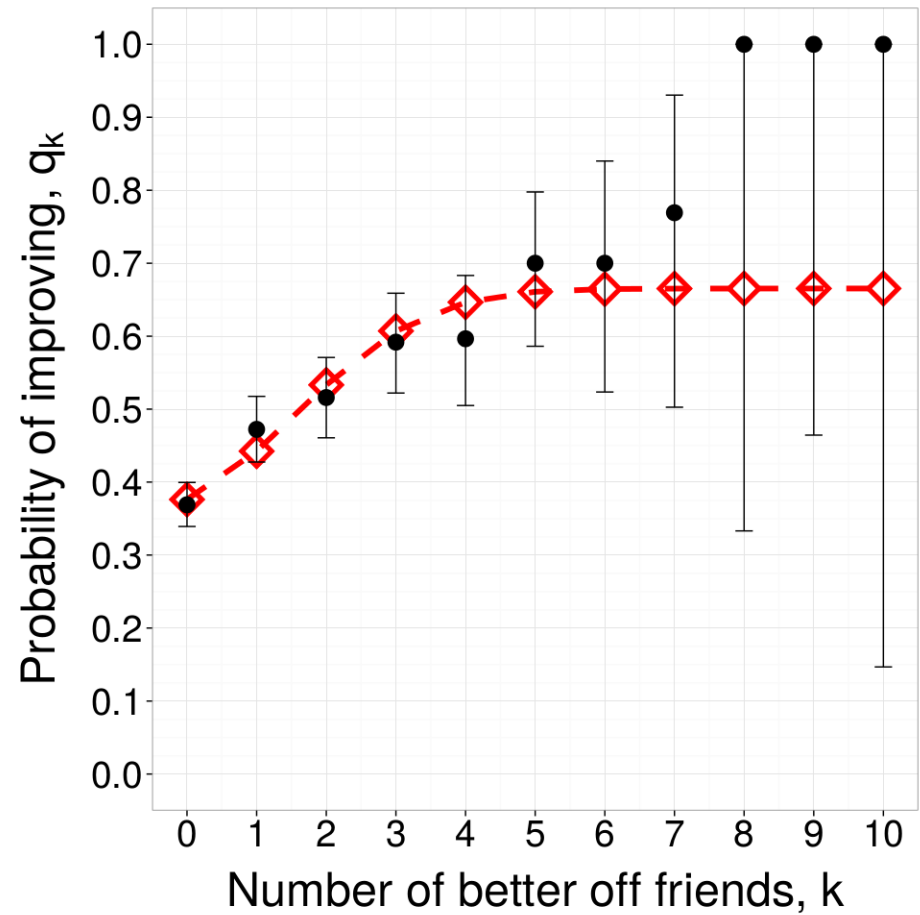
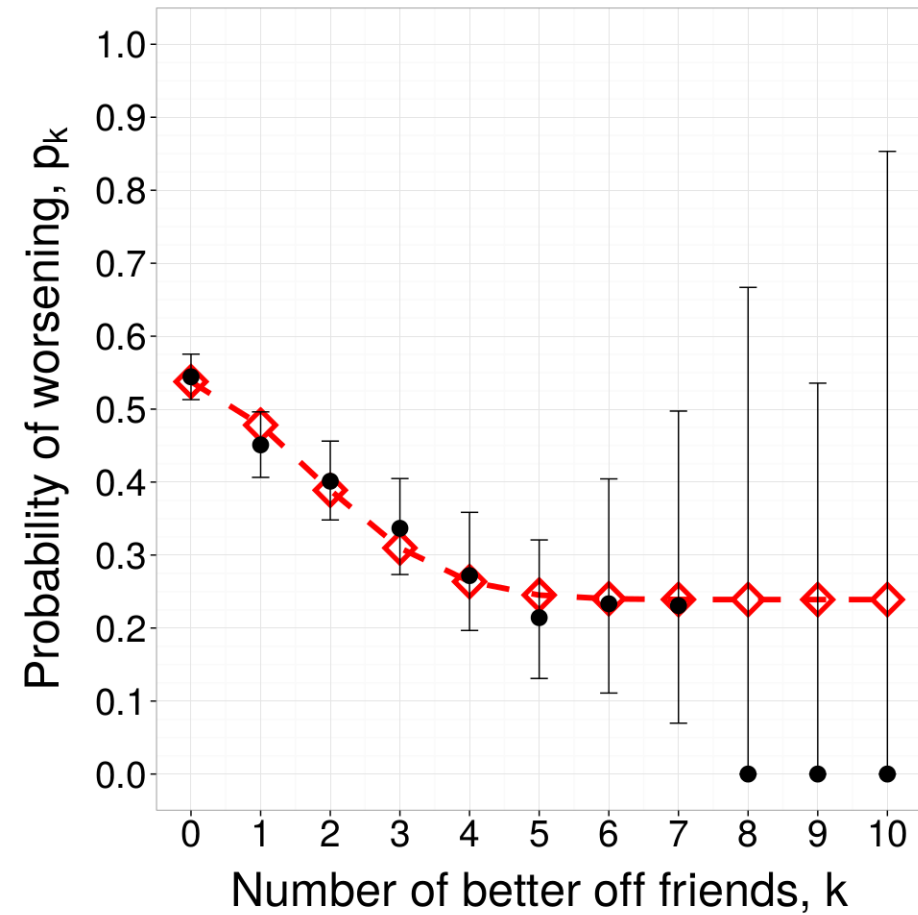
Improving transmits

Competing models assessed using standard statistical methods.

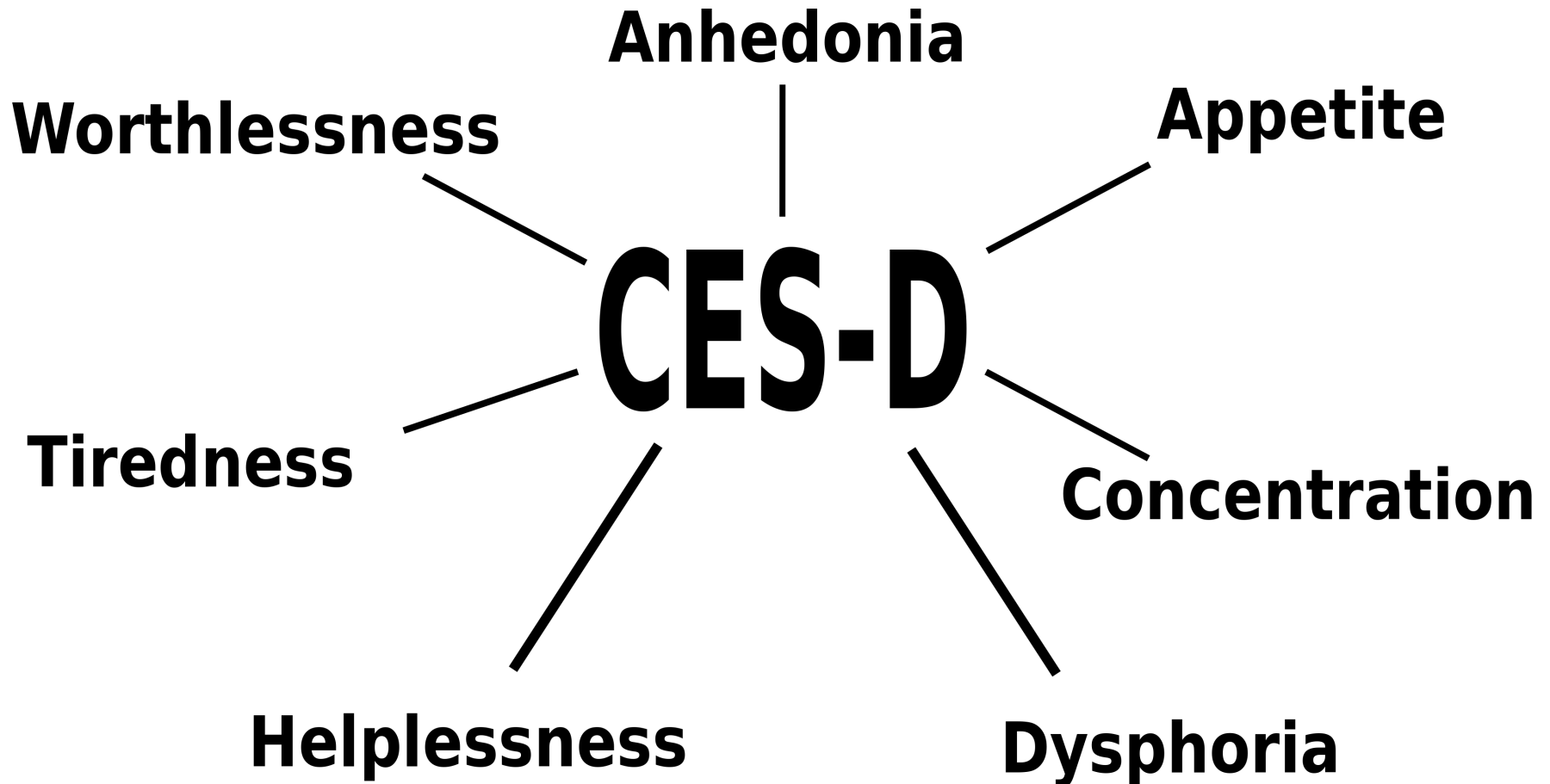
Total CES-D Score



Total CES-D Score



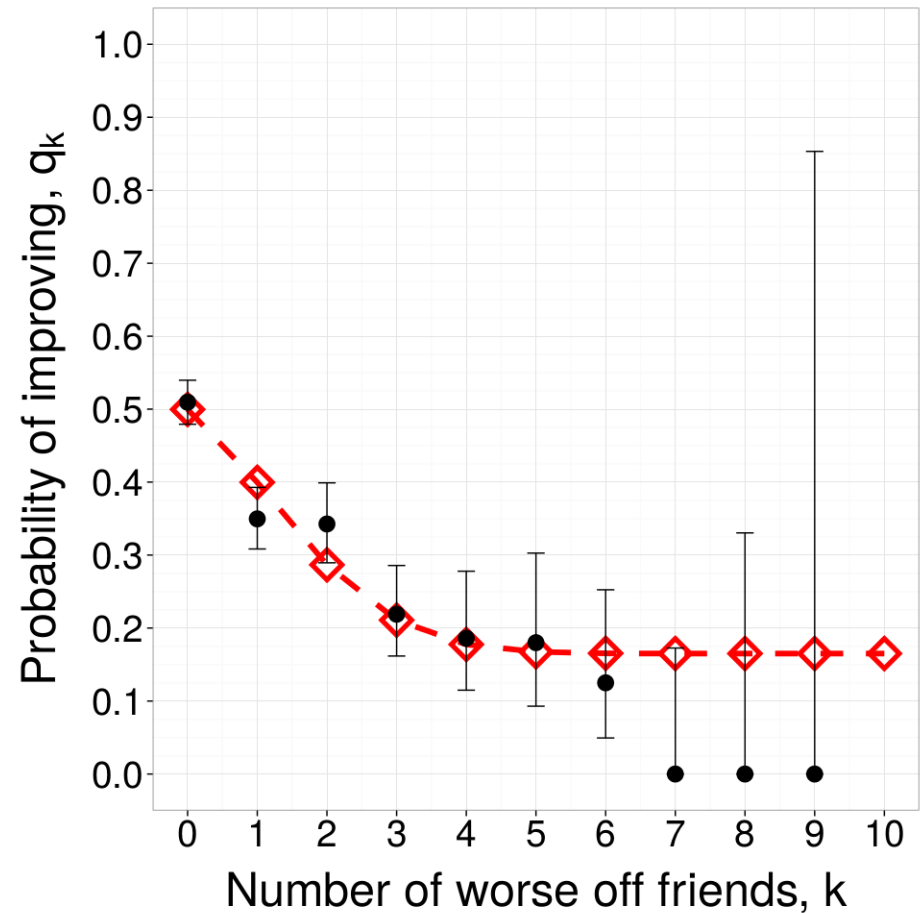
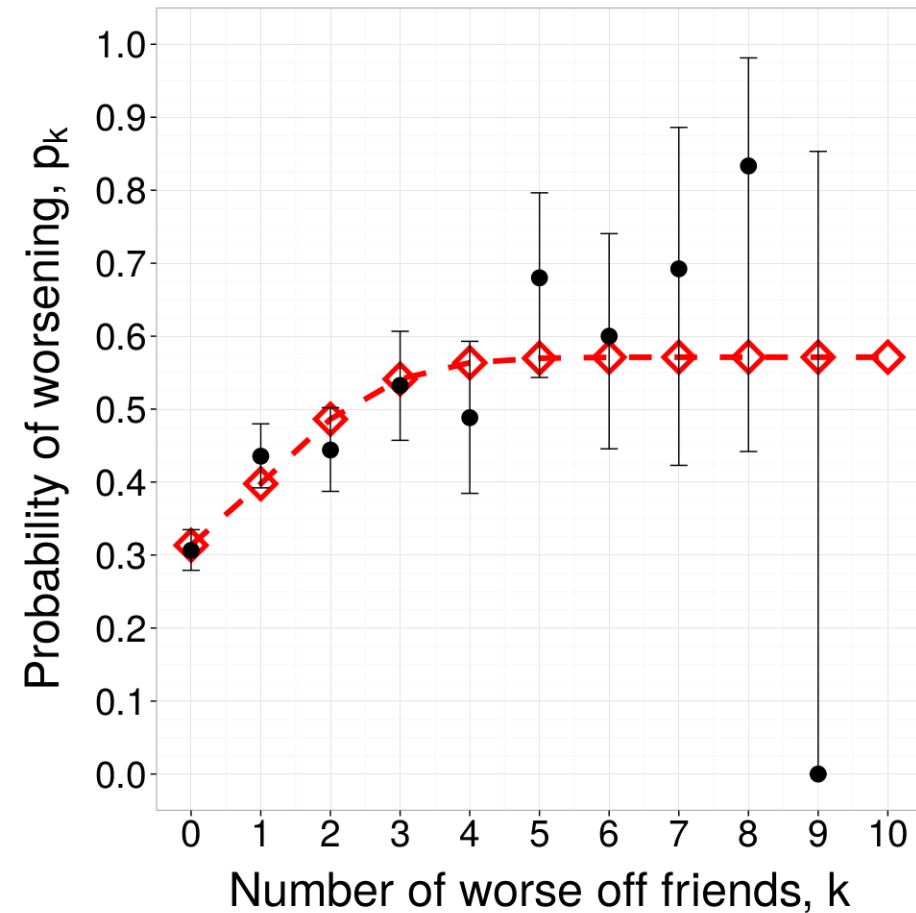
Component symptoms



References:

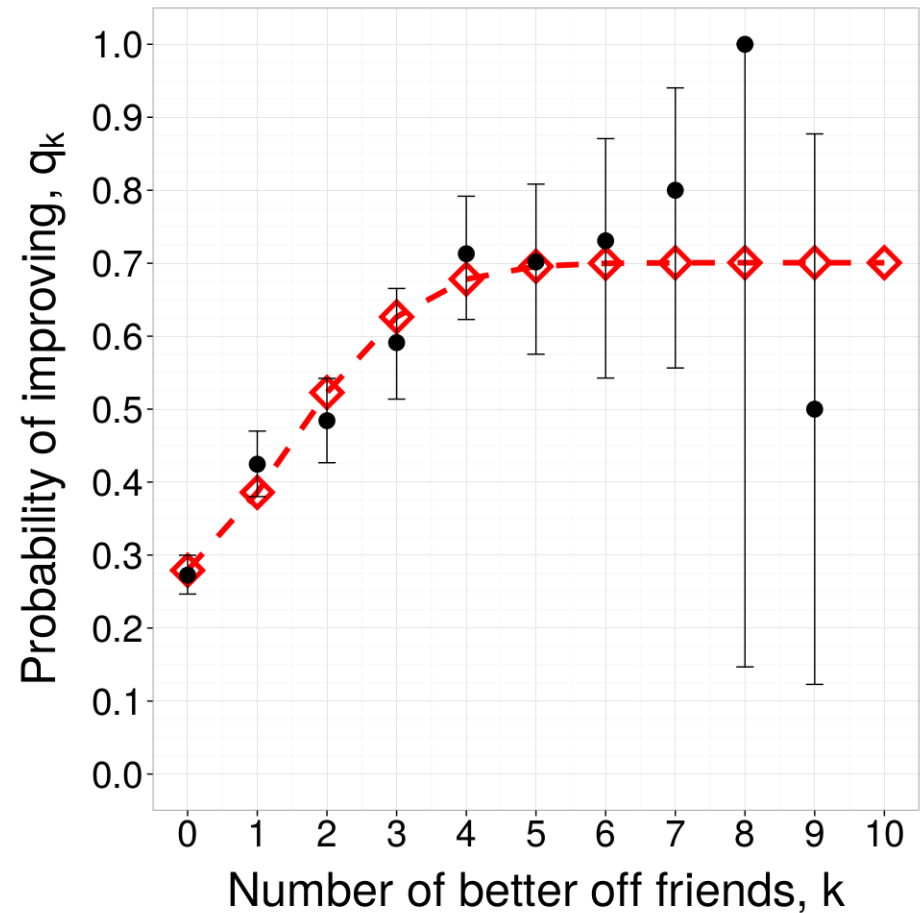
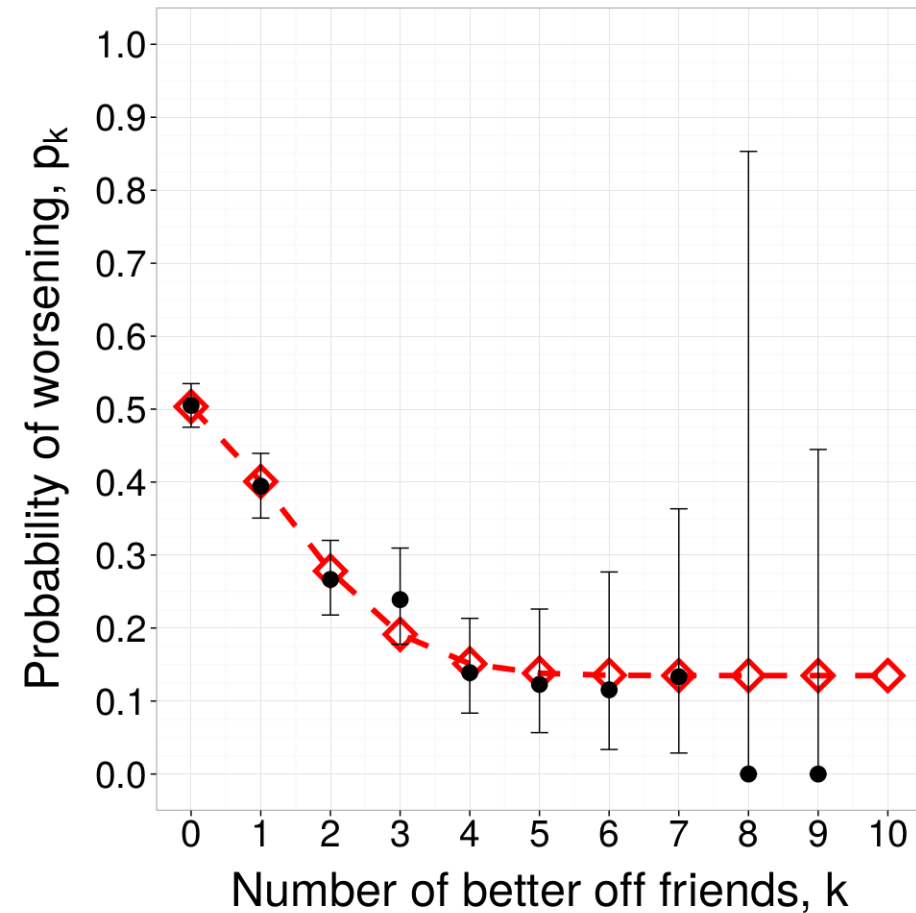
LS Radloff. (1977) The CES-D Scale: a self-report depression scale for research in the general population. *Appl. Psych. Meas.* **1**, 385-401.

Helplessness



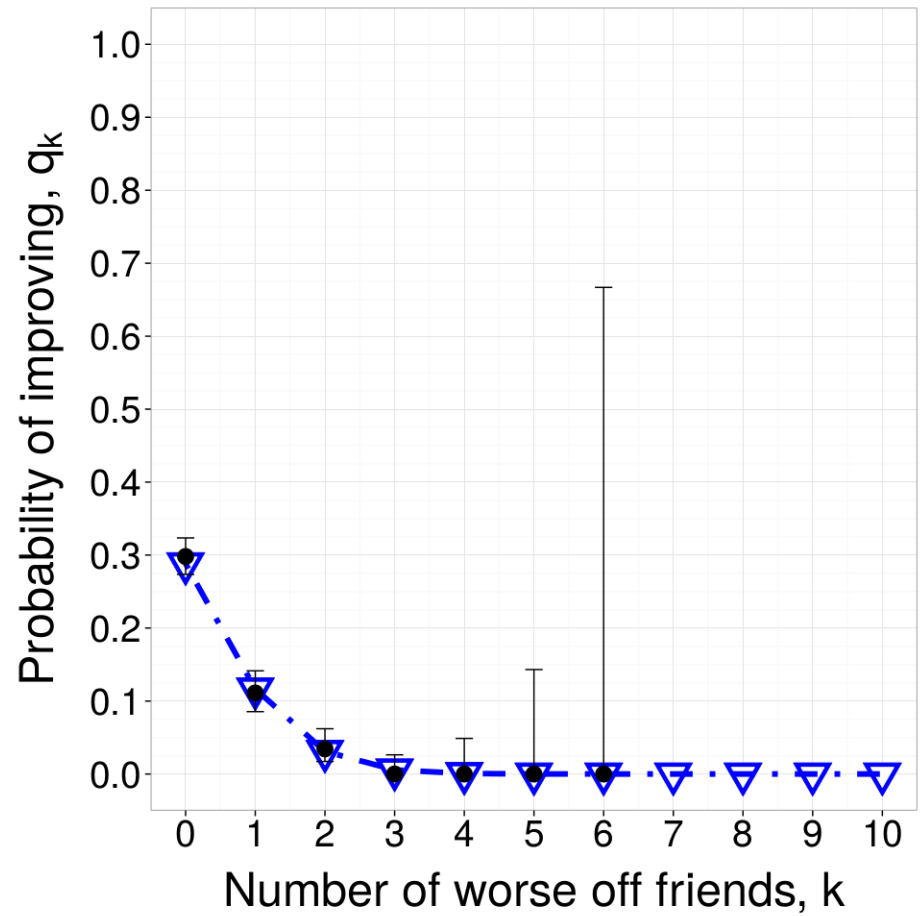
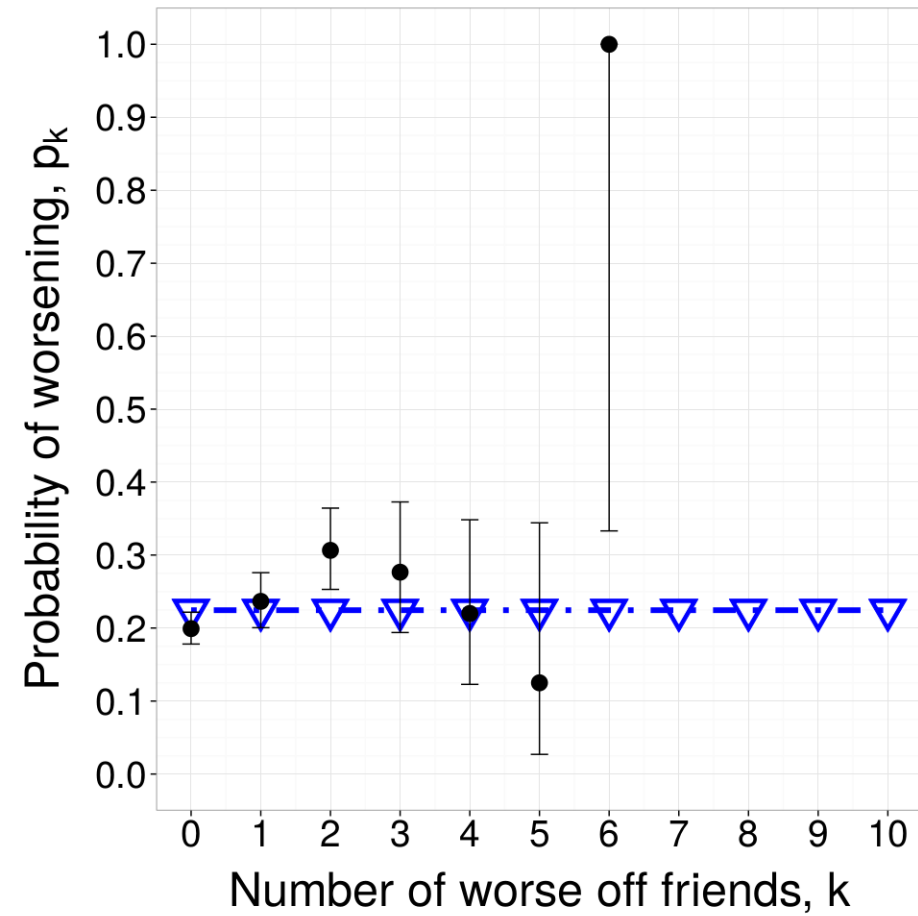
Similar - anhedonia, concentration, dysphoria, tiredness, worthlessness.

Helplessness

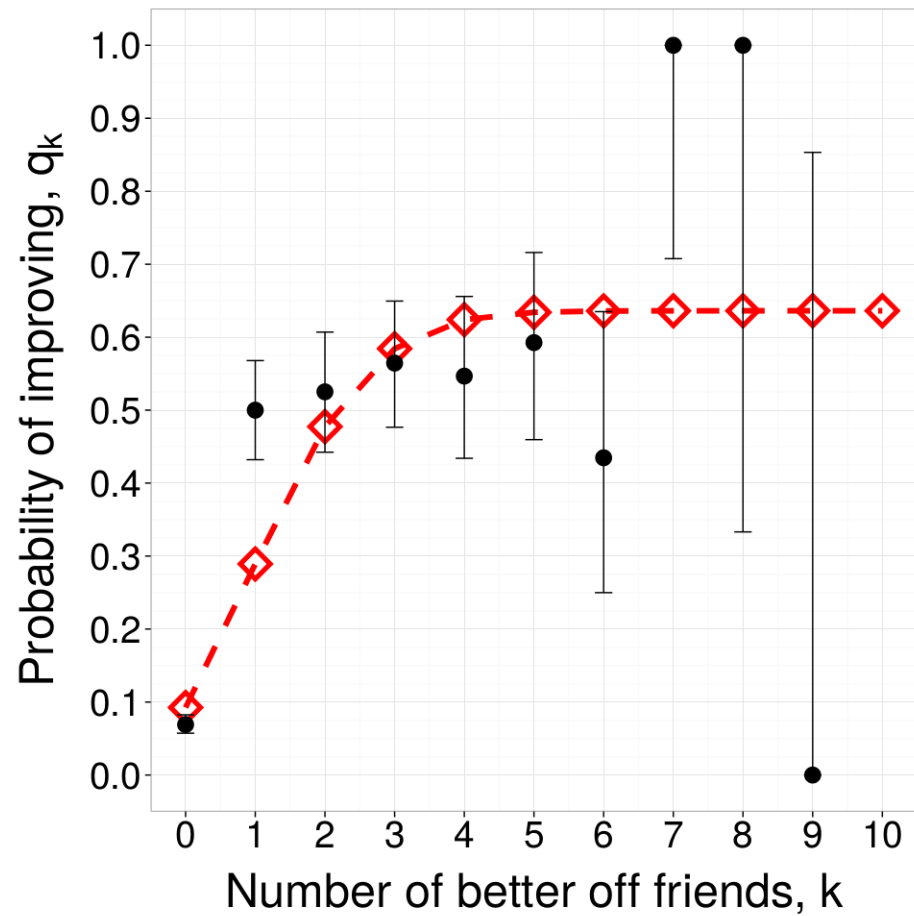
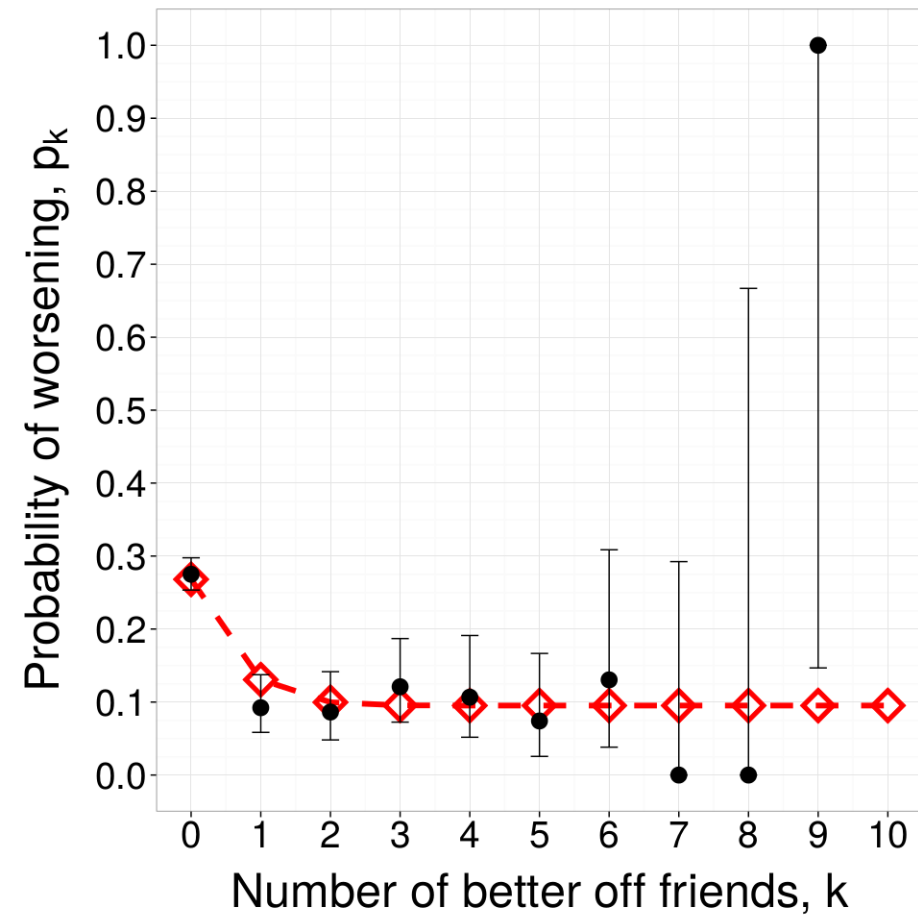


Similar - anhedonia, concentration, dysphoria, tiredness, worthlessness.

Appetite

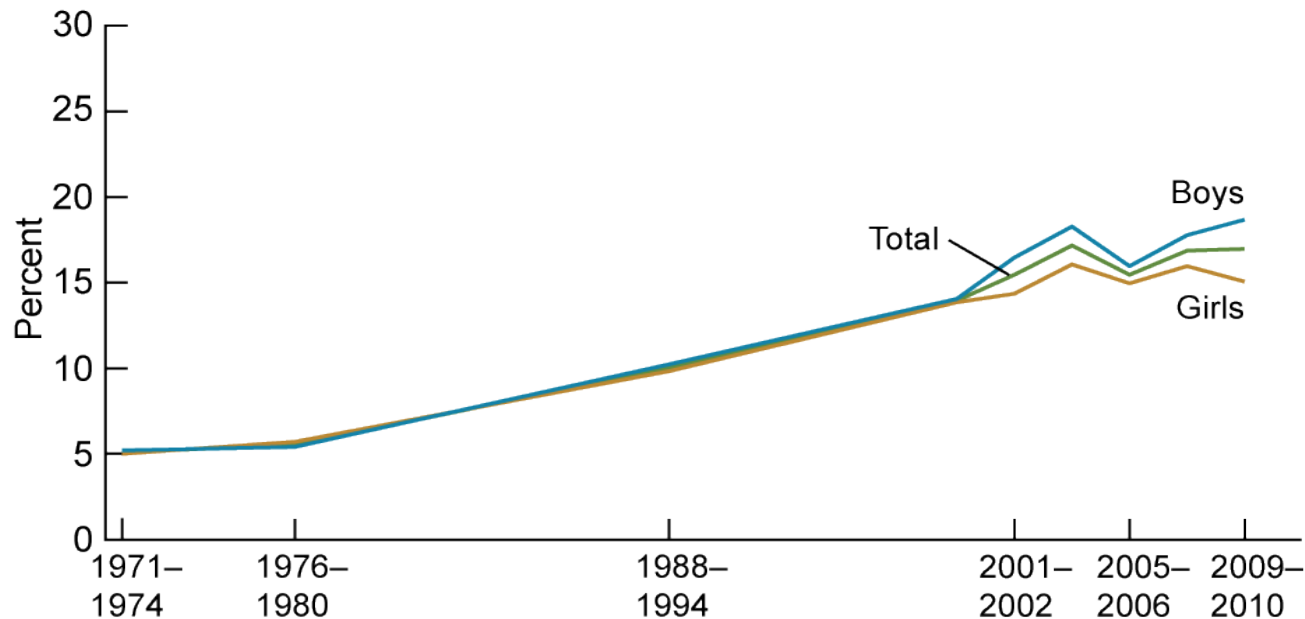


Appetite



Obesity

Figure 1: Trends in obesity among children and adolescents aged 2–19 years, by sex: United States, 1971–1974 through 2009–2010



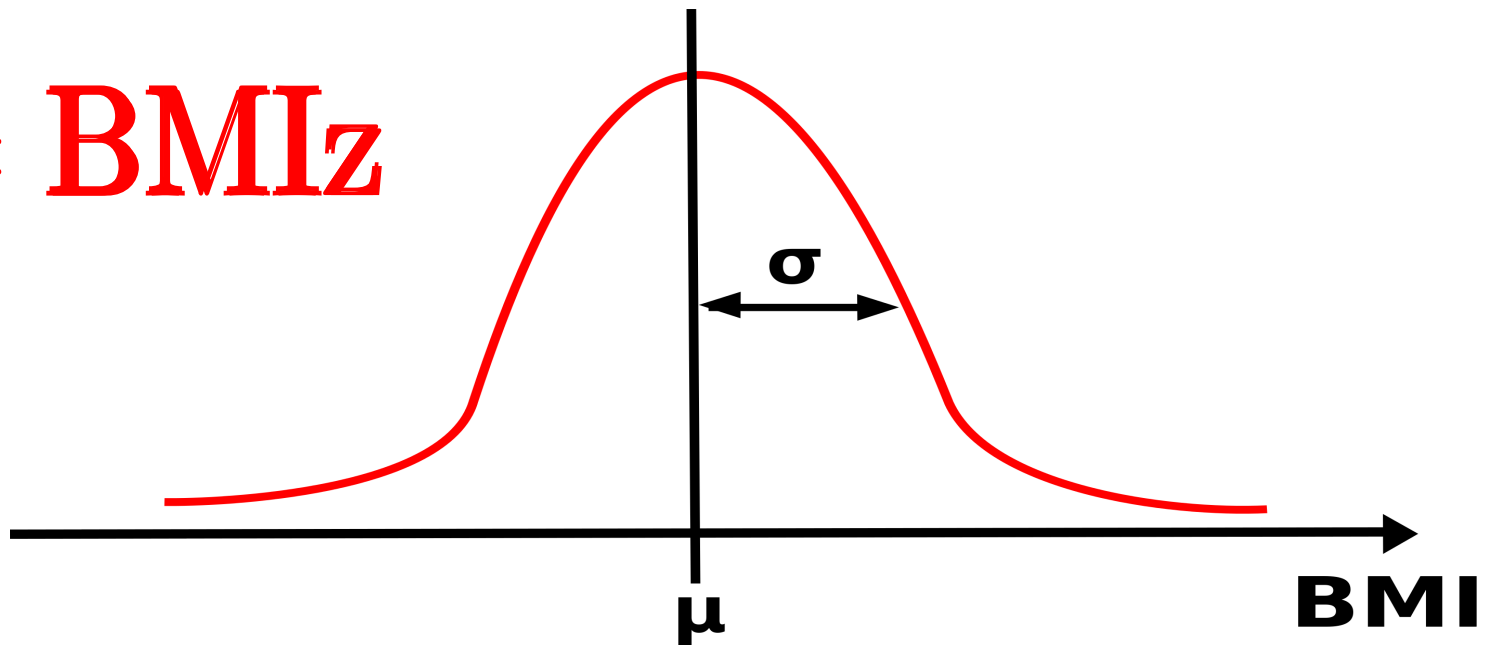
NOTE: Obesity is body mass index greater than or equal to the 95th percentile of the sex- and age-specific 2000 CDC growth charts.
SOURCES: CDC/NCHS, National Health and Nutrition Examination Surveys (NHANES) I–III; and NHANES, 1999–2000, 2001–2002, 2003–2004, 2005–2006, 2007–2008, and 2009–2010.

References:

Fryar, C. D., Carroll, M. D., & Ogden, C. L. (2012). Prevalence of obesity among children and adolescents: United States, trends 1963–1965 through 2009–2010. National Center for Health Statistics, 1960-2002.

$$\text{BMI} = \frac{\text{weight [lb]}}{(\text{height [in]})^2} \times 703$$

$$X_i = \text{BMI}z$$



References:

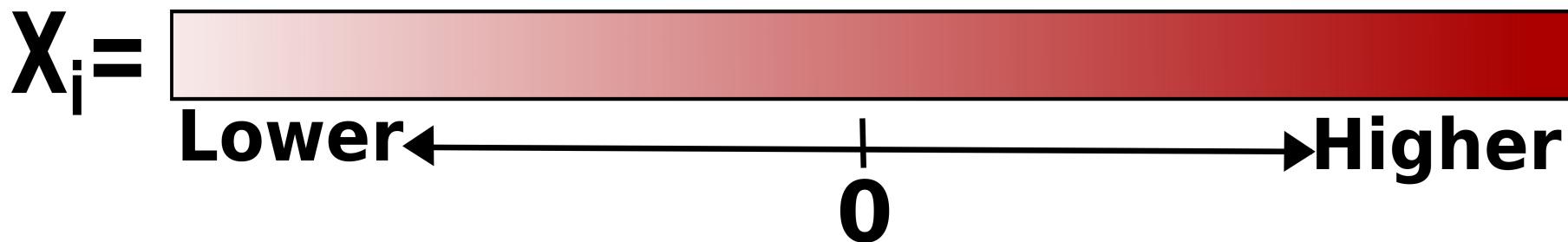
CDC (2014) About bmi for children and teens. URL

http://www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/about_childrens_bmi.html

CDC. (2009) Percentile data files with lms values. URL

http://www.cdc.gov/growthcharts/percentile_data_files.htm

Threshold



(1) No threshold

$$|X_i(t+1) - X_i(t)| > 0$$

(2) 0.2 threshold

$$|X_i(t+1) - X_i(t)| \geq 0.2$$

References:

Sacher, P. M. et al. (2010) Randomized Controlled Trial of the MEND Program: A Family-based Community Intervention for Childhood Obesity. *Obesity*, 18: S62-S68. doi: 10.1038/oby.2009.433.

The Data

The National Longitudinal Study of Adolescent to Adult Health (Add Health)



Friendship
network

- Allowed to list up to 5 male and 5 female friends.

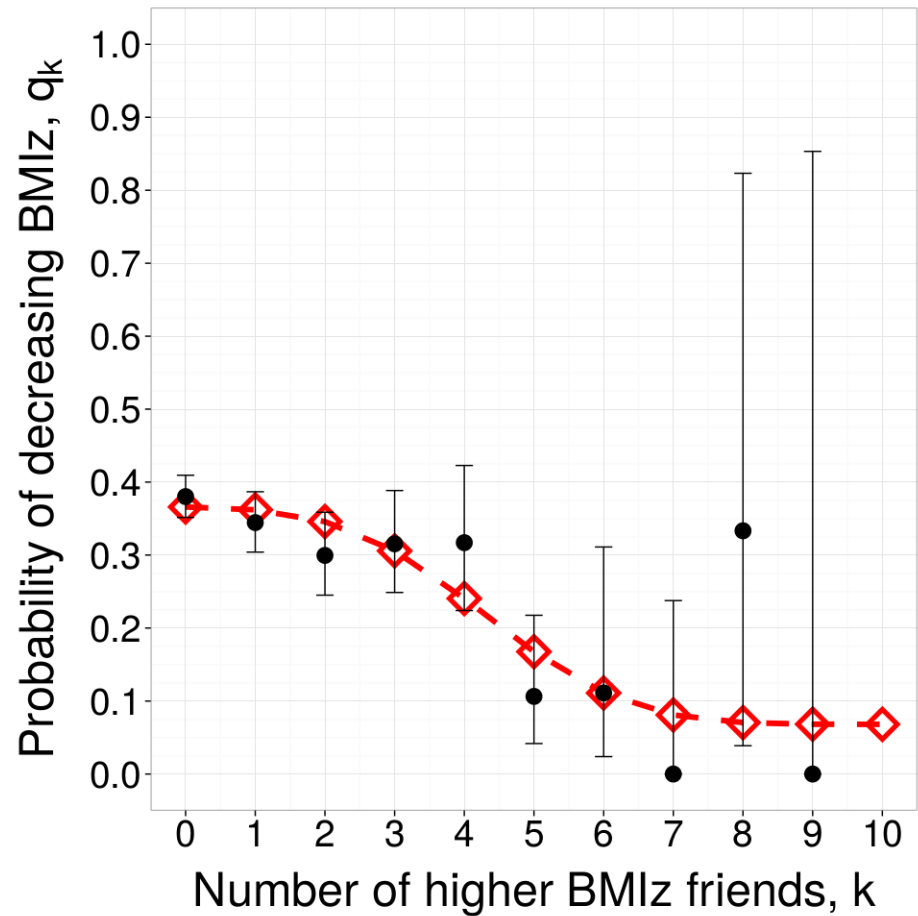
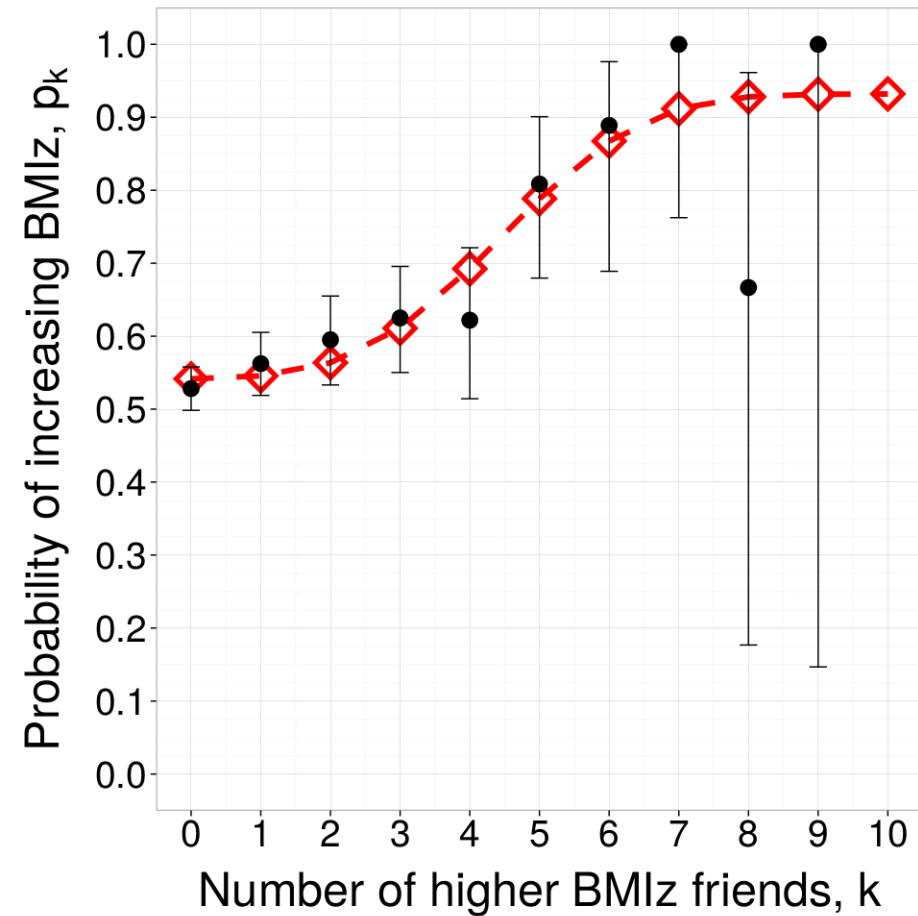


Weight, height,
age, and gender

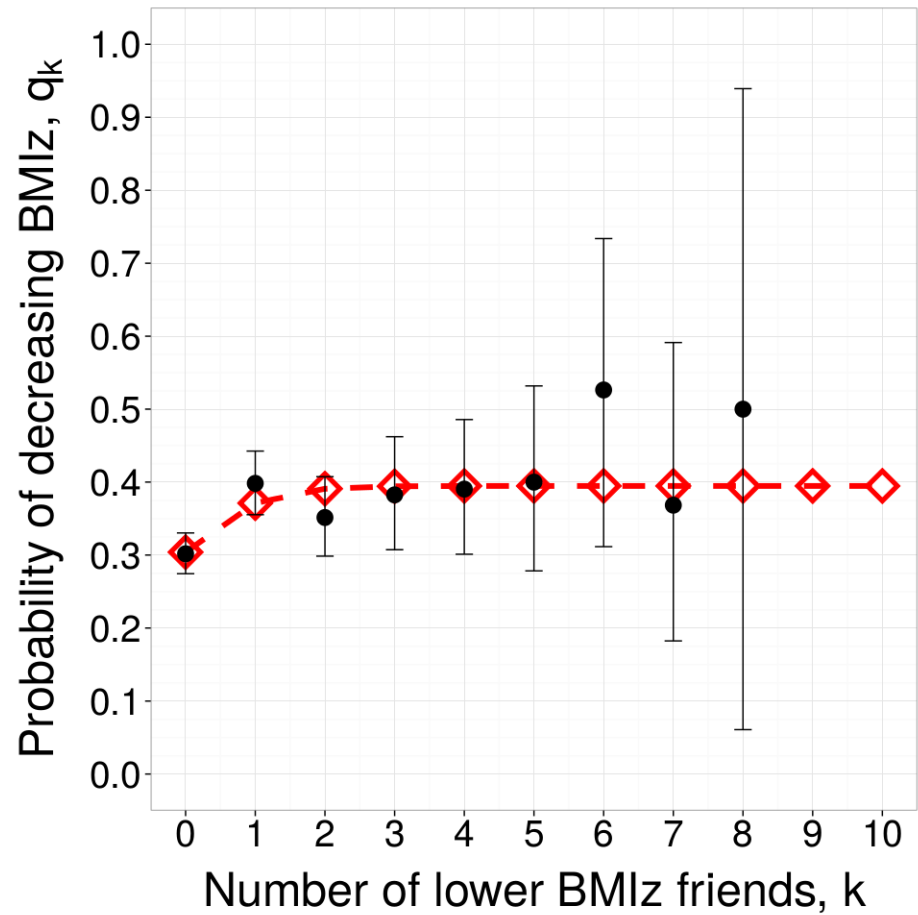
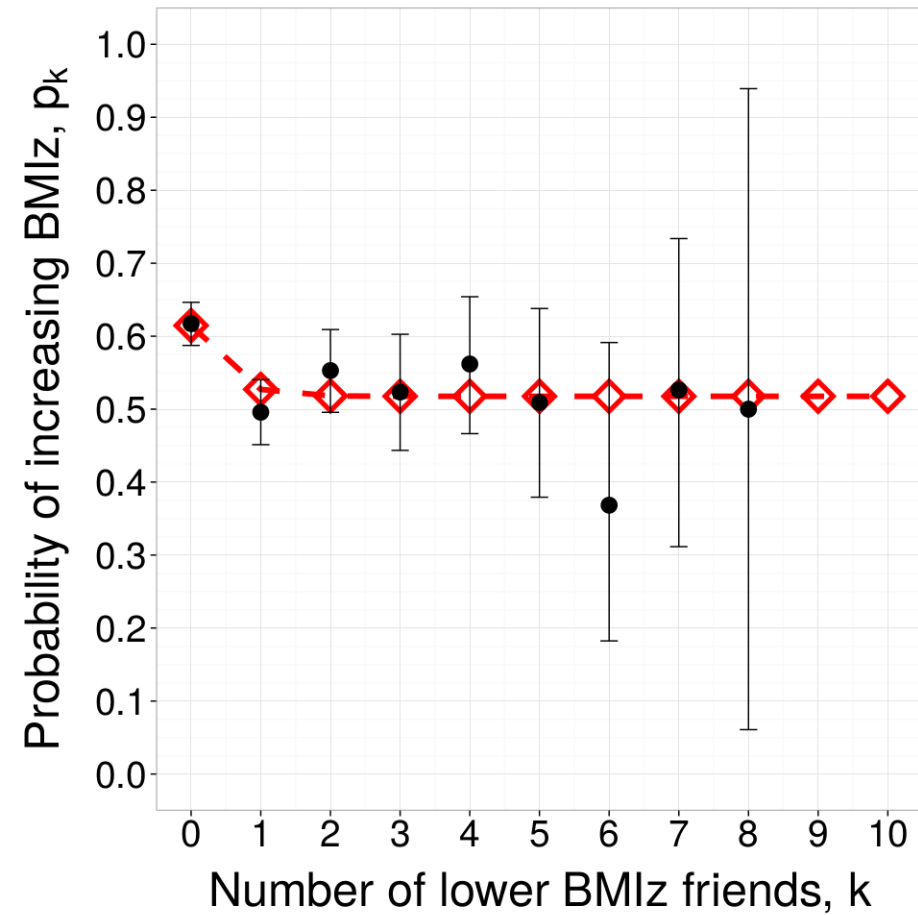
- Complete for both waves 1 and 2.

N = 2161

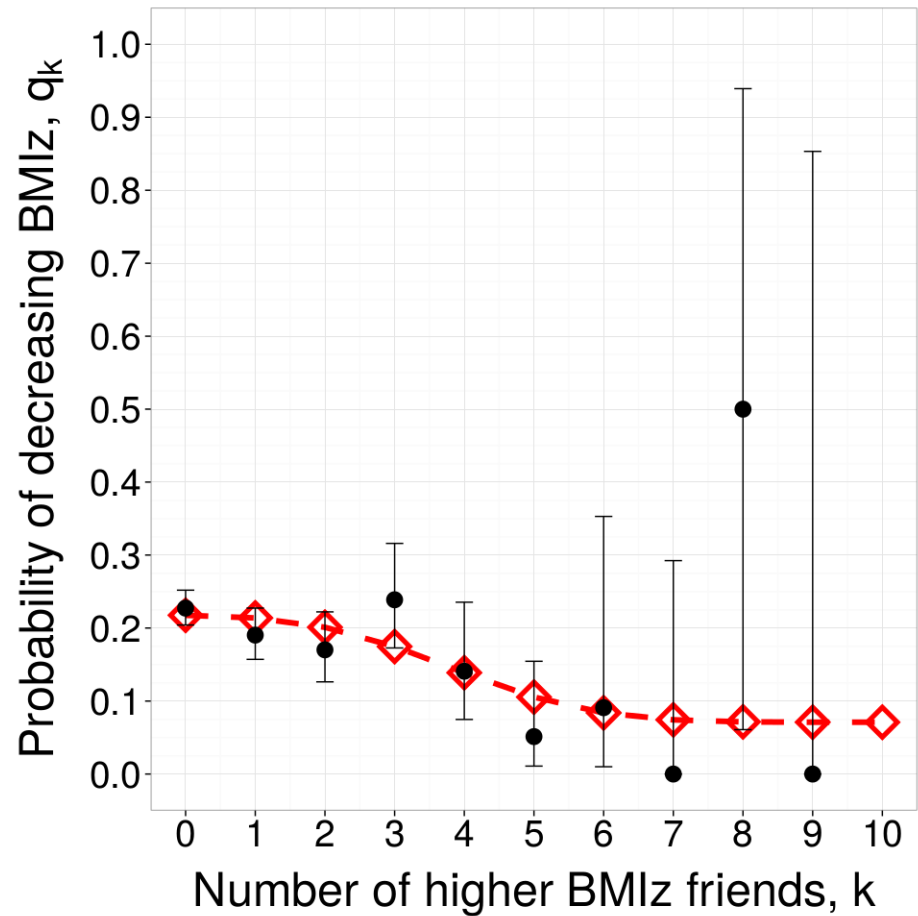
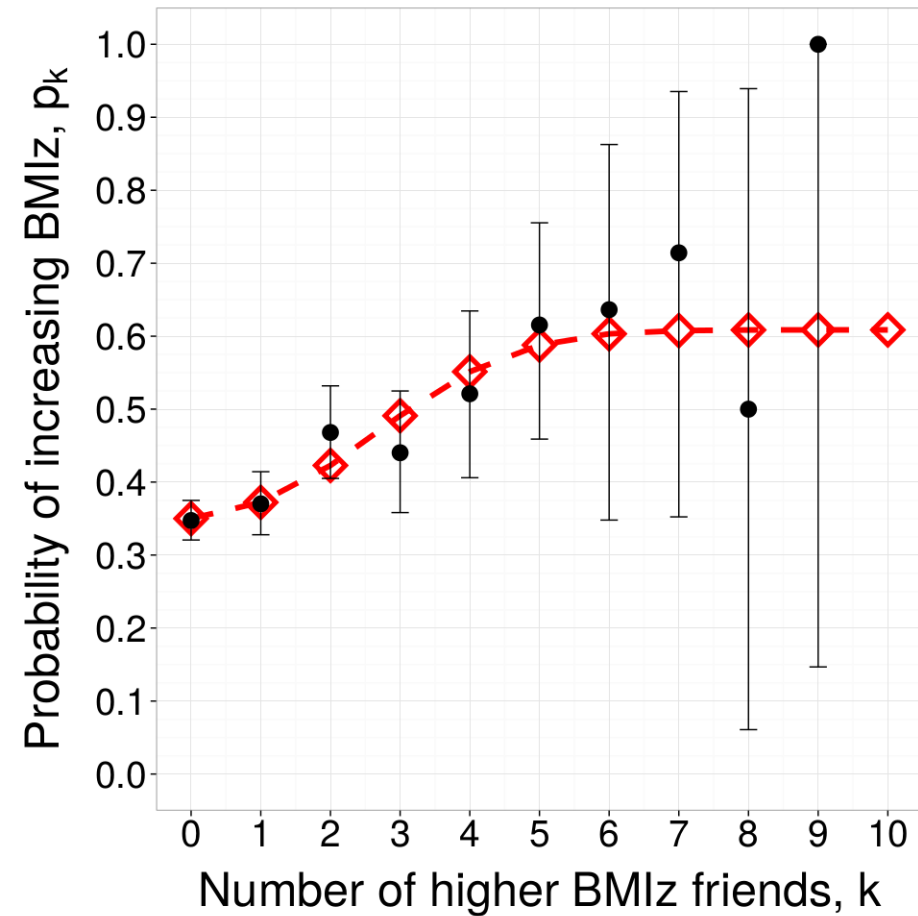
Weight - no threshold



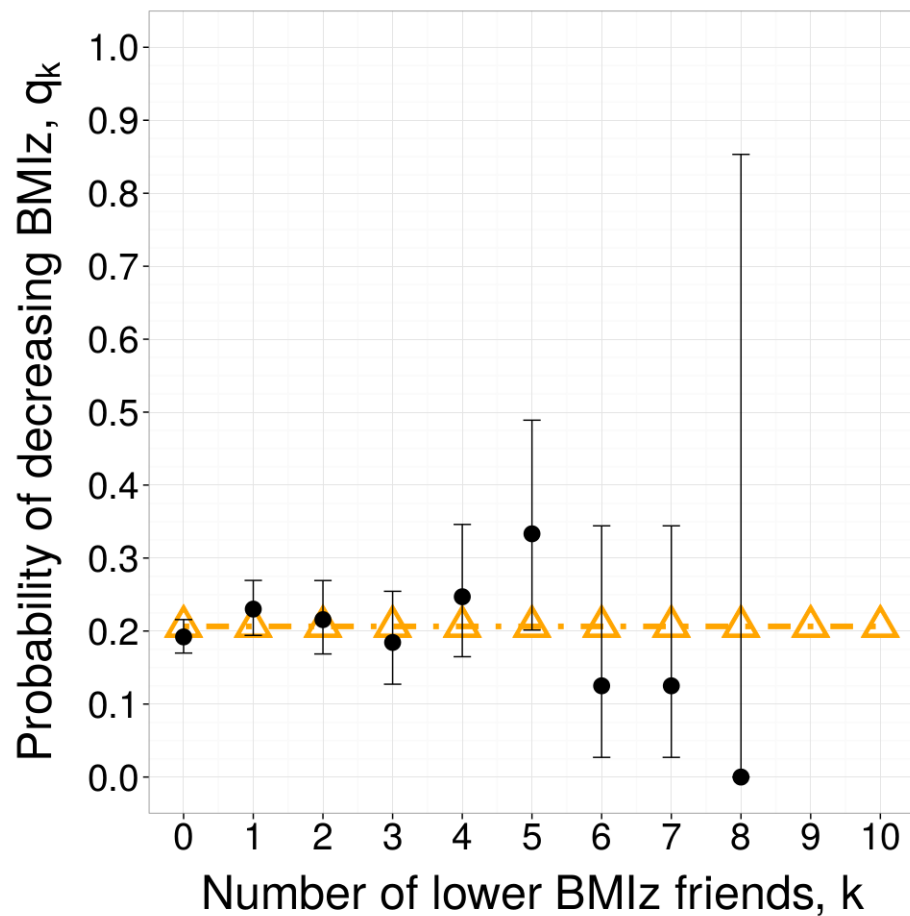
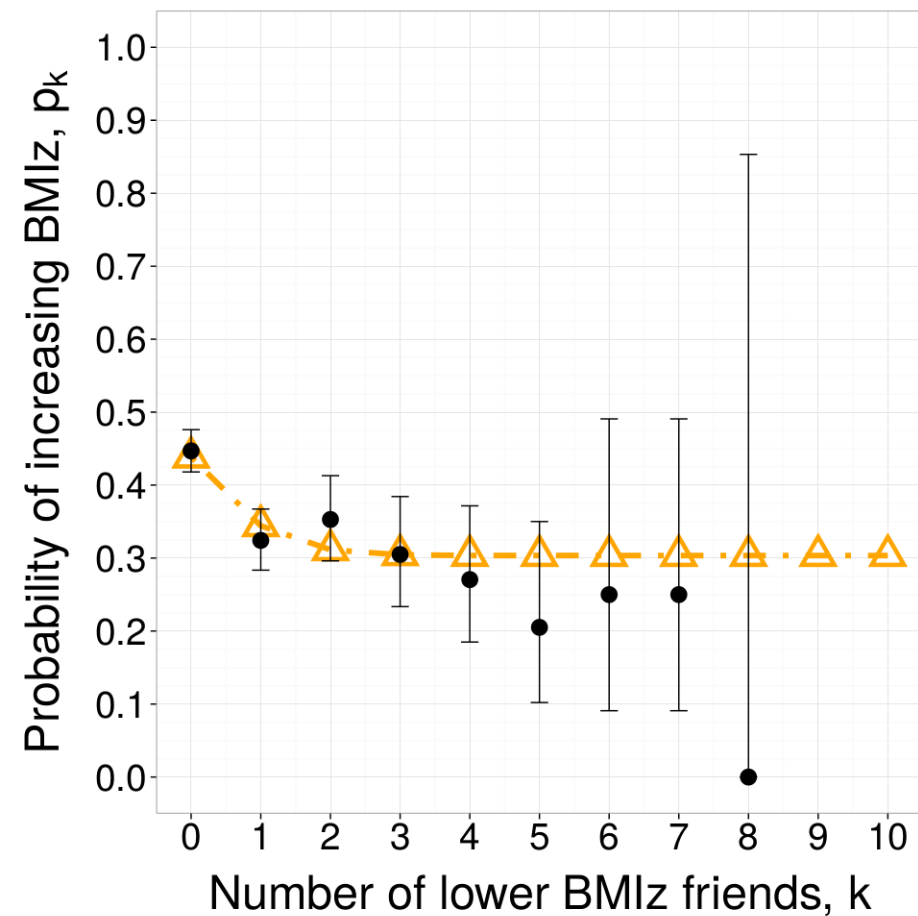
Weight - no threshold



Weight - 0.2 threshold



Weight - 0.2 threshold



Further work

- I Threshold
- Goodness-of-fit
- Further development of model
- Pregnancy “contagion”



Agincourt

MRC/Wits Rural Public Health and Health Transitions Research Unit



Frances Griffiths



Thomas House

The banner features mathematical models of disease spread: $\frac{dS}{dt} = \mu - \beta SI + \mu S$, $\frac{dI}{dt} = \beta SI - \mu I - \gamma I$, and $\frac{dR}{dt} = \gamma I - \mu R$. It also includes the text "Warwick Infectious Disease Epidemiology Research" and a grid of images showing a rainbow, a person in a pink protective suit, a sheep, a cow, a hand, and a sign that reads "FOOT & MOUTH DISEASE - PREVENTION PLEASE STAY OFF LAND".

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EPSRC

Engineering and Physical Sciences
Research Council

