**Health Behavior Trajectories over the Transition to Adulthood:
Similarity across Behaviors and Social Ties**

Rachel Margolis [1]
Jonathan Daw [2]

Abstract

During the transition to adulthood, many unhealthy behaviors are developed which in turn shape behaviors, health, and mortality in adulthood. Research on unhealthy behaviors and risky transitions has mostly focused on one health problem at a time. In this paper, we examine variation in health behavior trajectories taken, how similar they are across behaviors, and to what extent these trajectories are shared by siblings and friends in adolescence. We use the National Longitudinal Study of Adolescent Health (Add Health) Waves 1-4 to chart the most common health behavior trajectories over the transition to adulthood for cigarette smoking, alcohol consumption, obesity, and exercise. We examine to what extent health behavior trajectories are similar across the range of behaviors. Last, we examine how similar friends and siblings are in their health behavior trajectories.

[1] Corresponding author: Department of Sociology, University of Western Ontario, Social Science Center #5326, London, Ontario N6A 5C2, Canada.
Email: rachel.margolis@uwo.ca

[2] Department of Sociology, University of Alabama-Birmingham
Email: jddaw@uab.edu

Background

Health behaviors throughout the life course affect trajectories of chronic disease development and mortality (Rogers, Hummer and Nam 2000). During the transition to adulthood, many unhealthy behaviors are developed which in turn shape behaviors, health and mortality in adulthood (Hawkins, Catalano and Miller 1992). Recent research has examined the predictors of unhealthy behaviors and risky transitions (Boardman and Alexander 2011, Harris, Perreira and Lee 2009, Marshal et al. 2009, Yang et al. 2008). However, most work has focused on one health problem or behavior of the individual (Harris, Perreira and Lee 2009, Pollard et al. 2010, van den Bree, Whitmer and Pickworth 2004). Better understanding how behavioral patterns unfold jointly over time has the potential to shed new light on important health problems. For instance, alcohol and tobacco use are related (Grant 1998, Weitzman and Chen 2005), and the health consequences of this combination of behaviors may be greater than the sum of its parts (Castellsague et al. 1999, Kalman et al. 2010), though this claim is somewhat in dispute (Mukamal 2006). Furthermore, little previous research has examined how the trajectories of health behaviors cluster within social networks longitudinally. In this paper, we examine variation in health behavior trajectories taken, how similar they are across behaviors, and to what extent these trajectories are shared by siblings and friends in adolescence.

The United States has the highest rates among rich countries of risky behaviors and chronic disease incidence in young adulthood (Warren et al. 2006), which is an important contributor to the fact that the U.S. lags behind other rich countries in life expectancy (Preston and Stokes 2011). Given the clear links between health behaviors and chronic disease incidence, designing effective interventions must rely on data about how patterns of risk behaviors change over age. In contrast, although previous research has contributed a great deal to our

understanding of adolescent health behaviors and cross-sectional patterns, relatively few previous investigations have researched how patterns of health behavior change over the life course and how these trajectories are associated within social networks. Moreover, the extent to which risk behaviors cluster together can inform program design as well as theories about engagement in risky health behaviors.

To what extent are health behavior trajectories into adulthood shaped by one's social context in adolescence? Social relationships in adolescence provide a benchmark for which one develops norms about health behaviors and health management (Eisenberg et al. 2005, Smith and Christakis 2008, Thombs and Hamilton 2002). Although much prior research has investigated how health behaviors cluster in social networks (Daw, Margolis and Verdery forthcoming; Pollard et al. 2010; Christakis and Fowler 2008; 2007), and debated whether these patterns are attributable to contagion or selection effects (Cohen-Cole and Fletcher 2008; Fowler and Christakis 2008; McPherson et al. 2001; Shalizi and Thomas 2011), no previous research of which we are aware has examined how patterns of homophily evolve through the life course. Accordingly, we examine how similar health behavior trajectories are for siblings and friends in adolescence. Moreover, we test whether siblings and friends have similar health behavior patterns and identify important turning points for when their health behavior trajectories may diverge.

This paper brings together multiple strands of research. We examine how health behavior trajectories evolve over time, how risk trajectories cluster together, and how they are linked to social contexts. Not only are these health behavior trajectories important for health outcomes, but they also are an important part of the development of a health lifestyle and can be a part of the identity of young adults.

Health Behavior Trajectories from Adolescence to Adulthood

One open question about health behavior trajectories over the transition to adulthood is how they co-evolve from adolescence through the transition to adulthood. Are they positively or negatively correlated? Do some behaviors cluster together while others do not? On the one hand, all negative, risky behaviors may cluster together. Problem Behavior Theory (PBT) suggests that all negative health behaviors result from a person's tendency towards unconventionality or underlying riskiness (Jessor et al. 1991; 1977; Osgood and Wilson 1990). This idea of a single health-compromising lifestyle (Elliot 1993) would predict that all negative health behavior cluster together and that trajectories would also be positively correlated with each other. If this is the case, then the multiple negative lifestyle factors may have synergistic effects on health and mortality.

Alternatively, it could be that health behavior trajectories are not all positively correlated. One reason for this is the biological links between health behaviors. For example, one's ability to do physical activity may be limited by the decreased lung capacity of smokers. Similarly, common genetic influences may increase the likelihood of pursuing pairs of behaviors such as drinking and smoking (Daw, Nowotny and Boardman 2013). However, this is unlikely to explain all behavioral combinations. Second, some groups of health behaviors may be chosen together in order to fulfill health goals. For example, one might increase physical activity, decrease drinking, and smoke in order to lose weight. (Bish et al. 2005; Jeffery et al. 2000; Klesges and Klesges 1998). A third theory explaining why health behavior trajectories do not cluster together is that people may reward themselves for making one change with another unhealthy behavior. For example, allowing oneself to smoke may be a gift for doing more exercise (Audrain-McGovern et al. 2003).

Although there have been many studies examining one health behavior trajectory over the transition to adulthood (Oesterle et al. 2004; Pollard et al. 2010), while others have modeled an underlying latent cluster of health behaviors (Frech 2012; Marshal et al. 2009; Wang et al. 2012), far fewer have examine how multiple behaviors cluster together. One example is Frazier et al. (2001) which examines how cigar use is correlated with other high risk behaviors at a point in time. Previous research has also examined trends in the co-use of tobacco and alcohol in adolescence (Daw, Nowotny and Boardman 2013), but this study did not examine health behavior trajectories. Another study examines how trajectories of cannabis and alcohol use are correlated among people in Australia (Patton et al. 2007). Many studies have examined the relationship between smoking and physical activity (see Kaczynski et al. 2008 for a review). Although most studies find that smoking and physical activity are negatively correlated, some find a positive or insignificant associations. Most of these studies have either examined samples of adults or among selected samples, and among those using U.S. samples and samples of youth, results are very mixed (Kaczynski et al. 2008). In our paper, we examine a range of unhealthy behaviors among a representative sample of U.S. adolescents over the transition to adulthood, an important time for the formation of health risk behaviors. Moreover, we examine how these trajectories may be shaped by social ties.

The Social Context of Health Behavior Trajectories

Health behavior trajectories over the transition to adulthood are shaped by social context. Social relationships and social context can influence health behaviors through shaping the individuals' social environment and exposure to risks, influencing the availability of information and support for different behaviors, and affecting beliefs and attitudes through social norms and monitoring.

Health behaviors are thought to be influenced by the home environment (Bierut et al. 1998; Liefbroer and Elzinga 2012; Rende et al. 2005), school context (Alexander et al. 2001), neighborhood (Janssen et al. 2006; Mobley et al. 2006), and friend and peer groups (Eisenberg et al. 2005). Although it remains an open question to what extent "network effects" are due to direct influence or selection (Cohen-Cole and Fletcher 2008; Fowler and Christakis 2008; McPherson et al. 2001; Shalizi and Thomas 2011), there are important unanswered questions about how health behavior trajectories are situated in social networks. It remains unknown to what extent health behavior trajectories are shared among those with social ties and how long-lasting network effects are. Moreover, the degree of influence of adolescent social context on health behavior trajectory may vary by social groups. We therefore document the similarity of health behavior trajectories across different social ties and examine what explains the degree of homophily among network pairs' trajectories.

Research Questions

In this paper, we address three research questions.

1. What are the most common health behavior trajectories over the transition to adulthood? We chart trajectories for cigarette smoking, alcohol consumption, BMI, and exercise.

2. Second, we examine to what extent health behavior trajectories are similar across the range of behaviors, and whether the clustering of trajectories differs by sex, race/ethnicity, and parental education.

3. Last, we examine the extent to which health behavior trajectories co-evolve among two types of social ties – adolescent friends and siblings. As we move forward with the paper, we will test several explanations for how trajectories co-evolve.

6

Data

To examine health behavior trajectories over the transition to adulthood, we use the National

Longitudinal Study of Adolescent Health (Add Health) Waves 1-4. There are two main strengths

of these data for this project. Most importantly, it includes questions about key health behaviors

for a large, nationally representative sample of respondents at four points during the transition to

adulthood. Moreover, the data also allow the analysis of similarities of trajectories for key dyads

– siblings and friends of respondents.

In this paper, we utilize two analytic samples. For our first two research questions, we use

the public use version of the in-school Add Health sample. The analytic sample is 6,504

respondents. For the third research question which addresses how trajectories co-vary for key

dyads, we utilize the full Add Health sample. This analytic sample includes between 20,704 and

20,774 respondents, for whom information is available for that particular health behavior.

Measures of health behaviors

We chart health behavior trajectories for four behaviors – smoking, drinking, obesity and

exercise/inactivity, which are important for chronic disease development and adult health and

mortality (Lantz et al. 1998; Rogers et al. 2000). Respondents were asked, "During the past 12

months, how often did you smoke cigarettes" and "During the past 12 months, how often did you

drink beer, wine, or liquor." Responses range from never, once or twice, once a month or less, 2

or 3 days a month, once or twice a week, 3-5 days a week, or nearly everyday." For our latent

class analysis, we examine binary variables for the health behaviors. For smoking, we examine

whether the respondent was a smoker or not. For drinking, we examine whether the respondent

drinks more than 2-3 times per month or more. Obesity is calculated at each wave by dividing weight in kilograms by height in meter squared, with the cutoff at BMI of 30 or above.

Respondents were asked about different types of exercise that they did in the last week. In the first two waves, they were asked about the following activities, "Roller-blading, roller-skating, skate-boarding, bicycling, active sports such as baseball, softball, basketball, soccer, swimming or football, and exercise such as jogging, walking, karate, jumping rope, gymnastics, or dancing. Response categories were, not at all, 1-2 times, 3-4 times, 5 or more times per week, refused, and don't know. In waves 3 and 4 of the survey, the exercise variables include similar activities the respondent participated in the last week, such as biking, skateboarding, dancing, hiking, hunting, yard work, rollerblading, roller skating, skiing, snowboarding, racquet sports, aerobics, strenuous team sports, individual sports, gymnastics, weight lifting, strength training, golfing, fishing, bowling, or walking for exercise. For each wave, we estimate how many times per week respondents exercised and coded a binary variable for exercise – whether they partook in 3 or more activities per week.

For our mixed models, health behaviors are coded as continuous variables. Smoking and drinking scores are coded from questions about how often the respondent smoked or drank in last 30 days. Responses range from never (0), once or twice (1), once a month or less (2), 2 or 3 days a month (3), once or twice a week (4), 3 to 5 days a week (5), or nearly everyday (6). BMI is coded as a continuous variable. Inactivity is as the degree of inactivity in the last week. It is coded as the reverse of the number of reports of exercise per week and ranges from 0 to 15.

Sibling and friend network measures

We examine to what extent health behavior trajectories are similar for siblings and friends. Sibling tie identifiers are drawn from the Add Health pairs dataset, including twins, full siblings, and half siblings. This set only includes sibling ties between pairs of individuals selected for the in-home survey. We examine all available sets of sibling ties. Because Add Health oversampled twins, half siblings, adopted children, and step-siblings were oversampled, but not full siblings (Harris et al., 2006), this biases our sibling sample toward less common sibling types. As we move forward with the analysis, we will examine how sensitive our results are to this by documenting similarity in health behavior trajectories by sibling pair type.

Friendship ties are drawn from the in-school survey in Wave 1, in which every respondent had the opportunity to nominate their five best male friends and five best female friends. We examine whether people who defined themselves as friends in adolescence have similar health behavior trajectories. We examine all pairs between which a friendship nomination was sent. Analyzing *all* nominations of friendship, regardless of who nominated whom, as indicating friendship ties, helps expand the coverage of our friendship networks beyond the maximum of ten out-going nominations, because individuals can be nominated by others in the network, but it does not guarantee full coverage. Using these methods and data, we found 2,050 sibling ties and 102,888 friendship ties.

Methods

First, we use latent class analysis to describe the most common health behavior trajectories over the transition to adulthood. We estimate how many classes best fit the data on each health behavior trajectory (cigarette smoking, heavy alcohol consumption, obesity, and physical

9

activity). Latent class analysis estimates the sizes and characteristics of a model with n classes, and then examines the log odds of an individual i falling into a given class relative to the reference class. LCA models were estimated using the LCA stata plugin and all models were weighted (Lanza et al. 2011; LCA Stata Plugin Version 2013). This part of the analysis was conducted using the public use Add Health file. These results are shown in Table 1.

After estimating the classes for each age group, we predict the probability that each individual falls into each of the latent classes. Then we examine the extent to which trajectories co-vary across the range of behaviors using the public use data file. We examine how the probabilities of being in different trajectory classes are correlated and whether the correlation coefficients are statistically significant at the .05 level. These results are in Table 2 and Table A1.

To address how similar the trajectories of siblings and friends are over time, we proceed in three steps. First, we estimate unconditional growth models with no specified independent variables, with separate models estimated for each health behavioral outcome of interest. The purpose of these models is to obtain individual trajectory components (intercepts and linear slopes), which is the second step. The third step is to match friend and sibling pairs' health behavior trajectories together and estimate the correlations between these characteristics within each pair. Rather than simply examining these correlations within each wave, these descriptive analyses adopt a longitudinal perspective, examining correlations not only in level (as in the intercept) but also change over time. These results are presented in Table 3.

Results

First, we examine what patterns characterize the most common health behavior trajectories over the transition to adulthood. We estimate four classes for cigarette smoking and alcohol consumption and three classes for obesity and exercise. These are shown in Table 1. For each of the four behaviors, there is a trajectory characterized by increasing unhealthiness, always healthy, and always unhealthy. For cigarette smoking and alcohol consumption, there is also a category for increasing healthiness over time. The largest category in the smoking trajectory is never smokers (35%), followed by continuous smokers (28%), increasing smoking over time (22%), and finally, decreasing smoking over time (14%). For alcohol consumption, the four categories are more similar in size with just over a quarter decreasing drinking over time (28%), increasing drinking over time (27%) and a quarter never drinking heavily (24%) and 21 percent drinking throughout. For obesity and exercise, the largest categories are the healthy categories, with two thirds never being obese and 40 percent always exercising. However, increasing unhealthiness is also a common trajectory, including 22 percent for obesity and 24 percent for decreasing exercise. Ten percent of respondents are always obese and 37 percent never exercise more than three times per week.

Next, we address how health behavior trajectories co-vary across behaviors. Table 2 presents correlations in the probabilities of being in similar health behavior trajectories across the four behaviors. First, the table shows the correlations in the probabilities of being in the always unhealthy groups, then the always healthy trajectories, and then the increasing unhealthiness groups. We find that some health behaviors are clustered together more than others. Smoking and alcohol consumption are the most correlated behaviors. There is a 0.31 correlation for the probabilities of being in the always unhealthy trajectory for these two behaviors, a 0.46

correlation for being in the always healthy trajectories, and a 0.33 correlation for being in the increasing unhealthiness group for these behaviors. The next strongest correlation is the negative correlation between drinking and obesity. There is a -0.10 correlation between being in the always drinking and always obese category, a -0.13 correlation between never obese and never drinking, and a -0.14 correlation between being in the increasing unhealthy categories for these two behaviors.

There are moderate but significant correlations between three other sets of variables – obesity and exercise, smoking and exercise, and smoking and obesity. Being in the always obese trajectory is positively associated with never exercising (0.08) and never being obese is correlated with always exercising (.05). Similarly, there is a positive and statistically significant correlation between smoking throughout the transition to adulthood and never exercising (.06), always exercising and never smoking (.04) and increasing smoking and decreasing exercise (.03). The last interesting correlation between the behaviors is the one between obesity and smoking. The negative correlation between these two health behaviors is apparent in the bottom two parts of Table 2. There is a -0.11 correlation between never smoking and never being obese and a similar correlation for increasing smoking and increasing obesity.

The results presented in Table 2 are a subset of the full results of correlations for all health behavior trajectories, shown in Table A1. The results shown in both of these tables suggest that there does not seem to be an unhealthiness that correlates across all four health behavior trajectories. Rather, some of these behaviors are clustered together more than others.

Table 3 addresses question 3, the degree to which individual trajectory components in these health outcomes are correlated within sibling and friendship pairs. The top section of Table 3 presents the results of the unconditional mixed growth model which is used to obtain

12

individual trajectory components (intercepts and slopes). The first two rows indicate the estimated average intercepts and slopes; the next two rows indicate the cross-individual variance in these parameters; the fifth row depicts the covariance between these components; and the sixth row lists the number of unique observations involved in these calculations. Since for present purposes it is primarily the pair correlations that are of interest, this information is primarily provided for the reader's reference. Also, it is important to note that there is non-negligible variance for all of these parameters in these simple models, as well as negative covariance between the intercept and slope for all four behaviors.

The lower half of Table 3 presents the correlations in trajectory intercepts and slopes for siblings and friends. The correlations in these outcomes within sibling pairs are uniformly strong and typically moderate, ranging between 0.13 and 0.31 for slopes, and between 0.25 and 0.36 for intercepts. The intercepts are uniformly more highly correlated than the slopes across behaviors, with the slope/intercept correlation ratio ranging from about 0.5 for inactivity to 0.86 for drinking. Correlations in BMI are the largest for all behaviors for both intercepts and slopes. However, these trajectory characteristics are associated for all behaviors.

The results suggest that the correlations in these trajectory characteristics are stronger for sibling pairs than for friendship pairs. For all behaviors, the ratio of slope to intercept correlations is smaller for friendship pairs than that observed for siblings. This is particularly true for smoking, where the ratio is 0.35 (compared to 0.67 for siblings), and BMI, where the ratio is 0.43 (compared to 0.86 for siblings). Thus, for these outcomes, friendship ties have comparatively less long-lasting associations vis-à-vis sibling pairs. To a lesser degree this is true for all outcomes examined. The strongest intercept correlation is for smoking (0.23), and the strongest slope association is for drinking (0.10). Despite these comparatively weak effects,

however, the fact remains that persons who were friends in the in-school survey remain more similar than would be expected at random in their long-term health behavior trajectories.

Discussion

Health behaviors throughout the transition to adulthood are critical for shaping health in adulthood. Although much work has examined the predictors of unhealthy behaviors in adolescence, most research has addressed one behavior or problem and its predictors (Harris et al. 2009; Pollard et al. 2010; van den Bree et al. 2004) or examined how health behaviors are correlated at a point in time (Berrigan et al. 2003; Frazier et al. 2001; Satre et al. 2007). In this paper, we examine how health behavior *trajectories* cluster together during the transition to adulthood. The grouping of behavioral patterns can help us understand the development of health problems in adulthood and shed light on the causes of health disparities, if health behaviors interact thereby affecting health. Moreover, research has not addressed how health behavior trajectories cluster within social networks. Last, we examine how health behavior trajectories co-evolve among siblings and friends in adolescence.

Our first contribution addresses the extent to which health behavior trajectories are all clustered together, as Problem Behavior Theory would predict (Jessor et al. 1985; 1991; Osgood and Wilson 1990), or whether some behaviors are clustered together more than others, either due to biology or social factors (Bish et al. 2005; Jeffery et al. 2000; Klesges and Klesges 1998). We find a large degree of variation in how strongly pairs of health behavior trajectories cluster together. Smoking and drinking trajectories are the positively correlated and the most strongly of any of the health behavior combinations. This concurs with work on how correlated these behaviors are in adolescence (Grant 1998; Weitzman and Chen 2005). The second finding is that

14

smoking and obesity are negatively correlated. The correlation is less strong that the one between smoking and drinking, but more strongly than the other health behavior combinations. At the macro level, the increase in obesity over time is negatively correlated with the decline in smoking (Preston et al. 2013), however, this hasn't yet been shown within individual trajectories in young adulthood. This correlation may exist because of the biological changes that occur when quitting smoking which cause weight gain, or may be due to social factors. The next strongest correlation is the negative one between drinking and obesity. Never drinking is correlated with increasing and steady obesity, and always drinking is positively correlated with never being obese and negatively correlated with increasing obesity. This may be picking up the degree of social integration. Our measure of drinking is really picking up social drinking, not binge drinking. The last two correlations are moderate – healthy exercise is positively associated with not smoking, but not as strongly for other behaviors. And last, exercise and obesity are negatively correlated, but this relationship is not as strong as one would imagine. In summary, unhealthy behavior trajectories are *not* clustered together within a small segment of the population, as suggested by literature on SES differences in health behaviors. Rather, health behavior trajectories are varied, with some behaviors clustering together more than others.

Our final contribution presents the correlations in the trajectories of siblings and friends. Although previous research (Daw, Margolis and Verdery Forthcoming) has analyzed the cross-sectional homophily in sibling and friends' health behaviors, no previous research has examined these relationships longitudinally using nationally representative data. Our results indicate that siblings are moderately positively correlated in these behaviors both at the cross-section (as reflected in the correlations in intercepts) and longitudinally (as reflected in the correlations in slopes), particularly for cigarette smoking, alcohol consumption, and BMI. In comparison, friend

behaviors are less correlated at the cross-section and longitudinally, but the difference is especially large in the latter case, although positive correlations are still observed. Thus, siblings and friends remain more similar than expected at random in their trajectories for all four behaviors we examined, but this relationship is stronger for siblings than for friends, consistent with previous cross-sectional research (Daw, Margolis and Verdery Forthcoming).

Limitations and next steps

There are several limitations of our analysis, which we will address as we move our paper forward. First, our analysis is simple in the sense that we code health behaviors in a relatively crude manner for our latent class analysis. Moving forward, we will test the sensitivity of our results to our coding and examine alternative coding with more categories for the examined behaviors. Second, our measures of siblings include regular siblings as well as oversamples of twins, half siblings, adopted children and step-siblings. This biases our analysis toward these less common sibling types. Therefore, when moving forward, we will examine the correlations from our mixed models for different types of siblings and report these results. Third, we will examine different explanations for correlations in trajectories for siblings and friends. We will study whether similar education trajectories, geographic distance, and emotional distance can help to explain why some pairs have more similar trajectories than others. Fourth, our simple growth models allow only for linear trajectories; in the future we will examine whether our results vary when we permit non-linear trajectories. Fifth, our growth analyses treat Add Health waves as linear indicators of time; since the time between waves varies substantially (one year between waves I and II, whereas 8 years separate waves II, III, and IV), this mis-specifies the underlying time function. In future analyses we will seek ways to re-estimate these models using years

rather than waves as the measure of time. Finally, we will examine how patterns of health behavior co-evolution differ by demographic groups (gender, race, and social class) and how the different patterns of clustering may contribute to social disparities in health.

Despite limitations, this analysis adds to our understanding about how health behavior trajectories evolve over time and how they are linked to key network ties. Understanding these health behavior trajectories is important for understanding health trajectories in adulthood, and also for the shaping of one's health lifestyle, norms, and identity that develop over the transition to adulthood.

TABLES

Table 1. Latent classes for four health behavior trajectories, Add Health Public Use Sample, Waves I-IV

	Cigarette Smoking	**Alcohol Consumption**	**Obesity**	**Exercise**
Class 1: Increasing Healthiness	Decreasing smoking over time 14%	Decreasing drinking over time 28%	NA	NA
Class 2: Increasing Unhealthiness	Increasing smoking over time 22%	Increasing drinking over time 27%	Increasingly obese 22%	Decreasing exercise 24%
Class 3: Always Healthy	Never smoker 35%	Never heavy drinker 24%	Never obese 67%	Always exercise 40%
Class 4: Always Unhealthy	Always smoker 28%	Heavy drinker throughout 21%	Always obese 10%	Never heavy exercise 37%
Total	100%	100%	100%	100%

Table 2. Correlations in the probabilities of being in different latent classes of health behavior trajectories across behaviors, Add Health Waves I-IV

Correlations among probability of being in always unhealthy groups				
	Always smoke	**Always drink**	**Always obese**	**Never exercise**
Always smoke	1.00			
Always drink	0.31*	1.00		
Always obese	-0.02	-0.10*	1.00	
Never exercise	0.06*	-0.02	0.08*	1.00

Correlations among probability of being in always healthy trajectories				
	Never smoke	**Never drink**	**Never obese**	**Always exercise**
Never smoke	1.00			
Never drink	0.46*	1.00		
Never obese	-0.11*	-0.13*	1.00	
Always exercise	0.04*	-0.01	0.05*	1.00

Correlations among probability of being in increasing unhealthiness group				
	Increasing smoking	**Increasing drinking**	**Increasing obesity**	**Decreasing exercise**
Increasing smoking	1.00			
Increasing drinking	0.33*	1.00		
Increasing obesity	-0.11*	-0.14*	1.00	
Decreasing exercise	0.03*	0.00	0.00	1.00

Notes
* $p < .05$

Table 3: Within-Pair Correlations in Growth Parameters for Siblings and Friends, Add Health Waves I-IV

	Cigarette Smoking	Alcohol Consumption	BMI	Inactivity
Intercept	1.31**	2.79**	20.68**	8.96**
Slope	2.94**	-0.17**	1.90**	0.10**
Var (Intercept)	120.41	4.37	20.35	11.95
Var (Slope)	12.43	0.42	2.14	1.13
Cov (Intercept, Slope)	-25.64	-1.14	-1.28	-2.75
N (Unique)	20,758	20,769	20,704	20,774
Sibling Int. Corr.	0.35	0.25	0.36	0.25
Sibling Slope Corr.	0.23	0.21	0.31	0.13
Friend Int. Corr	0.23	0.15	0.14	0.16
Friend Slope Corr.	0.08	0.10	0.06	0.08

Notes:

* $p<0.05$; ** $p<0.01$

Cross-tie correlations are obtained by predicting individual intercepts and slopes from mixed growth models and correlating them within pairs.

Table A1. Correlations in the probabilities of being in different latent classes of health behavior trajectories across behaviors, Add Health Waves I-IV

Smoking vs. Drinking	Smoking				Drinking			
Smoking	Decreasing	Increasing	Always	Never	Decreasing	Increasing	Always	Never
Decreasing	1.00							
Increasing	-0.30*	1.00						
Always	-0.16*	-0.24*	1.00					
Never	-0.15*	-0.35*	-0.70*	1.00				
Drinking								
Decreasing	0.29*	-0.25*	0.01	0.02	1.00			
Increasing	-0.14*	0.33*	0.03*	-0.19*	-0.56*	1.00		
Always	-0.01	0.06*	0.31*	-0.34*	-0.31*	-0.04*	1.00	
Never	-0.15*	-0.10*	-0.33*	0.46*	-0.20*	-0.28*	-0.60*	1.00

Smoking vs. Obesity	Smoking				Obesity		
Smoking	Decreasing	Increasing	Always	Never	Never	Always	Increasing
Decreasing	1.00						
Increasing	-0.30*	1.00					
Always	-0.16*	-0.24*	1.00				
Never	-0.15*	-0.35*	-0.70*	1.00			
Obesity							
Never	-0.06*	0.10*	0.07*	-0.11*	1.00		
Always	-0.01	-0.03*	-0.02	0.05*	-0.61*	1.00	
Increasing	0.09*	-0.11*	-0.07*	0.10*	-0.76*	-0.05*	1.00

Smoking vs. Exercise	Smoking				Exercise		
Smoking	Decreasing	Increasing	Always	Never	Decreasing	Always	Never
Decreasing	1.00						
Increasing	-0.30*	1.00					
Always	-0.16*	-0.24*	1.00				
Never	-0.15*	-0.35*	-0.70*	1.00			
Exercise							
Decreasing	-0.05*	0.03*	0.01	-0.01	1.00		
Always	-0.02	0.05*	-0.07*	0.04*	-0.38*	1.00	
Never	0.05*	-0.07*	0.06*	-0.04*	-0.25*	-0.80*	1.00

Drinking vs. Obesity	Drinking				Obesity		
Drinking	Decreasing	Increasing	Always	Never	Never	Always	Increasing
Decreasing	1.00						
Increasing	-0.56*	1.00					
Always	-0.31*	-0.04*	1.00				
Never	-0.20*	-0.28*	-0.60*	1.00			
Obesity							
Never	-0.16*	0.17*	0.16*	-0.13*	1.00		
Always	0.06*	-0.08*	-0.10*	0.10*	-0.61*	1.00	
Increasing	0.15*	-0.14*	-0.11*	0.08*	-0.76*	-0.05*	1.00

Continued on next page

Table A1 continued

Drinking vs. Exercise	*Drinking*				*Exercise*		
Drinking	Decreasing	Increasing	Always	Never	Decreasing	Always	Never
Decreasing	1.00						
Increasing	-0.56*	1.00					
Always	-0.31*	-0.04*	1.00				
Never	-0.20*	-0.28*	-0.60*	1.00			
Exercise							
Decreasing	0.01	-0.00	-0.04*	0.03*	1.00		
Always	-0.09*	0.07*	0.04*	-0.01	-0.38*	1.00	
Never	0.09*	-0.08*	-0.02	-0.00	-0.25*	-0.80*	1.00

Obesity vs. Exercise	*Obesity*			*Exercise*		
Obesity	Never	Always	Increasing	Decreasing	Always	Never
Never	1.00					
Always	-0.61*	1.00				
Increasing	-0.76*	-0.05*	1.00			
Exercise						
Decreasing	0.02	-0.04*	-0.00	1.00		
Always	0.05*	-0.05*	-0.01	-0.38*	1.00	
Never	-0.06*	0.08*	0.02	-0.25*	-0.80*	1.00

Notes

* p<.05

References

Alexander, Cheryl, Marina Piazza, Debra Mekos and Thomas Valente. 2001. "Peers, Schools, and Adolescent Cigarette Smoking." *Journal of Adolescent Health* 29:22-30.

Audrain-McGovern, J., D. Rodriguez and H. B. Moss. 2003. "Smoking Progression and Physical Activity." Cancer Epidemiology, Biomarkers & Prevention: A Publication of the American Association for Cancer Research, Cosponsored by the American Society of Preventive Oncology 12:1121-9.

Berrigan, D. et al. (2003). Patterns of Health Behavior in U.S. Adults. *Preventative Medicine,* 36:615-623.

Bierut, Laura J., Stephen H. Dinwiddie, Henri Begleiter, Raymond R. Crowe, Victor Hesselbrock, John I. Nurnberger, Bernice Porjesz, Marc A. Schuckit and Theodore Reich. 1998. "Familial Transmission of Substance Dependence: Alcohol, Marijuana, Cocaine, and Habitual Smoking: A Report from the Collaborative Study on the Genetics of Alcoholism." *Archives of General Psychiatry* 55:982-8.

Bish, Connie L., Heidi M. Blanck, Mary K. Serdula, Michele Marcus, Harold W. Kohl and Laura K. Khan. 2005. "Diet and Physical Activity Behaviors among Americans Trying to Lose Weight: 2000 Behavioral Risk Factor Surveillance System." *Obesity Research* 13:596-607.

Boardman, J. D. and K. B. Alexander. 2011. "Stress Trajectories, Health Behaviors, and the Mental Health of Black and White Young Adults." *Social Science & Medicine* 72(10):1659-66.

Castellsague, X., N. Munoz, E. De Stefani, C. G. Victora, R. Castelletto, P. A. Rolon and M. J. Quintana. 1999. "Independent and Joint Effects of Tobacco Smoking and Alcohol Drinking on the Risk of Esophageal Cancer in Men and Women." *International Journal of Cancer* 82(5):657-64.

Christakis, N.A., & Fowler, J.H. 2007. The spread of obesity in a large social network over 32 years. *New England Journal of Medicine*, 357, 370-379.

Christakis, N.A., & Fowler, J.H. 2008. The collective dynamics of smoking in a large social network. *New England Journal of Medicine*, 358, 2249-2258.

Cohen-Cole, E., & Fletcher, J.M. 2008. Is obesity contagious? Social networks vs. Environmental factors in the obesity epidemic. *Journal of Health Economics*, 27, 1382-1387.

Daw, Jonathan, Kathryn M. Nowotny and Jason D. Boardman. 2013. "Changing Patterns of Tobacco and Alcohol Co-Use by Gender in the United States, 1976-2010." *Demographic Research.*

Daw, J., R Margolis. & A.M. Verdery. Forthcoming. Siblings, friends, course-mates, club-mates: How adolescent health behavior homophily varies by race, class, gender, and health status. *Social Science & Medicine.*

Eisenberg, M. E., D. Neumark-Sztainer, M. Story and C. Perry. 2005. "The Role of Social Norms and Friends' Influences on Unhealthy Weight-Control Behaviors among Adolescent Girls." *Social Science & Medicine* 60(6):1165-73.

Elliott, D. S. 1993. Health-Enhancing and Health-Compromising Lifestyles. In Millstein, S. G., Petersen, A. C., and Nightingale, E. O. (eds), Promoting the Health of Adolescents: New Directions for the Twenty-first Century. Oxford University Press, New York, NY, pp. 112–145.

Frazier, L.A., et al. 2001. Association of Adolescent Cigar Use With Other High-Risk Behaviors. *Pediatrics,* 106(26).

Frech, Adrianne. 2012. "Healthy Behavior Trajectories between Adolescence and Young Adulthood." *Advances in Life Course Research* 17:59-68.

Grant, B. F. 1998. "Age at Smoking Onset and Its Association with Alcohol Consumption and Dsm-Iv Alcohol Abuse and Dependence: Results from the National Longitudinal Alcohol Epidemiologic Survey." *Journal of Substance Abuse* 10(1):59-73.

Harris, Kathleen Mullan, Penny Gordon-Larsen, Kim Chantala, and Richard Udry. 2006. Longitudinal trends in race/ethnic disparities in leading health indicators from adolescence to young adulthood. *Archives of Pediatrics and Adolescent Medicine* 160(1):74-81.

Harris, K. M., K. M. Perreira and D. Lee. 2009. "Obesity in the Transition to Adulthood Predictions across Race/Ethnicity, Immigrant Generation, and Sex." *Archives of Pediatrics & Adolescent Medicine* 163(11):1022-28.

Hawkins, J. D., R. F. Catalano and J. Y. Miller. 1992. "Risk and Protective Factors for Alcohol and Other Drug Problems in Adolescence and Early Adulthood - Implications for Substance-Abuse Prevention." *Psychological Bulletin* 112(1):64-105.

Janssen I, Boyce WF, Simpson K, Pickett W. 2006. Influence of individual- and area-level measures of socioeconomic status on obesity, unhealthy eating, and physical inactivity in Canadian adolescents. *Am J Clin Nutr* 83:139–145.

Jeffery, Robert W., Deborah J. Hennrikus, Harry A. Lando, David M. Murray and Jane W. Liu. 2000. "Reconciling Conflicting Findings regarding Postcessation Weight Concerns and Success in Smoking Cessation." *Health Psychology* 19:242.

Jessor, Richard. 1991. "Risk Behavior in Adolescence: A Psychosocial Framework for Understanding and Action." *Journal of Adolescent Health* 12:597-605.

Jessor, Richard, Shirley L. Jessor, L. Dennerstein, G.D. Burrows, M.M. Mascarenhas, F.X. Meehan, G. Maloof, R.F. Vollman, M.E. Robertson and M. Bourgeois. 1977. "Problem Behavior and Psychosocial Development: A Longitudinal Study of Youth." America (New York) 137:19-22.

Kaczynski, Andrew T., Stephen R. Manske, Roger C. Mannell and Keerat Grewal. 2008. "Smoking and Physical Activity: A Systematic Review." *American Journal of Health Behavior* 32.

Kalman, D., S. Kim, G. DiGirolamo, D. Smelson and D. Ziedonis. 2010. "Addressing Tobacco Use Disorder in Smokers in Early Remission from Alcohol Dependence: The Case for Integrating Smoking Cessation Services in Substance Use Disorder Treatment Programs." *Clinical Psychology Review* 30(1):12-24.

Klesges, Robert C. and Lisa M. Klesges. 1988. "Cigarette Smoking as a Dieting Strategy in a University Population." *International Journal of Eating Disorders* 7:413-9.

Lantz, Paula M., James S. House, James M. Lepkowski, David R. Williams, Richard P. Mero and Jieming Chen. 1998. "Socioeconomic Factors, Health Behaviors, and Mortality." *JAMA: The Journal of the American Medical Association* 279:1703-8.

Lanza, S.T., Dziak, J.J., Huang L., Wagner, A.T., & Collins, L.M. 2011. LCA Stata plugin users' guide (Version 1.0). University Park: The Methodology Center, Penn State. Retrieved from methodology.psu.edu.

LCA Stata Plugin (Version 1.0) Software. 2013. University Park: The Methodology Center, Penn State. Retrieved from methodology.psu.edu.

Liefbroer, Aart C. and Cees H. Elzinga. 2012. "Intergenerational Transmission of Behavioural Patterns: How Similar are Parents' and Children's Demographic Trajectories?" *Advances in Life Course Research* 17:1-10.

Marshal, M. P., M. S. Friedman, R. Stall and A. L. Thompson. 2009. "Individual Trajectories of Substance Use in Lesbian, Gay and Bisexual Youth and Heterosexual Youth." *Addiction* 104(6):974-81.

McPherson, M., Smith-Lovin, L., & Cook, J.M. 2001. Birds of a feather: Homophily in social networks. *Annual Review of Sociology*, 27, 415-444.

Mobley LR, Root ED, Finkelstein EA, Khavjou O, Farris RP, Will JC. 2006. Environment, obesity, and cardiovascular disease risk in low-income women. *Am J Prev Med* 30:327–332.

Mukamal, K. J. 2006. "The Effects of Smoking and Drinking on Cardiovascular Disease and Risk Factors." *Alcohol Research & Health* 29(3):199-202.

Oesterle, S., K. G. Hill, J. D. Hawkins, J. Guo, R. F. Catalano and R. D. Abbott. 2004. "Adolescent Heavy Episodic Drinking Trajectories and Health in Young Adulthood." *Journal of Studies on Alcohol* 65:204-12.

Osgood, D.W., and Wilson, J. K. 1990. Covariation among health compromising behaviors in adolescents. In Contractor Documents Vol. 7: Adolescent Health: Time for a Change. U.S. Department of Commerce, National Technical Information Service, Washington, DC.

Patton, George C., Carolyn Coffey, Michael T. Lynskey, Sophie Reid, Sheryl Hemphill, John B. Carlin and Wayne Hall. 2007. "Trajectories of Adolescent Alcohol and Cannabis use into Young Adulthood." *Addiction* 102:607-15.

Pollard, M.S., J. S. Tucker, H.D. Green, D. Kennedy and M. Go. 2010. "Friendship Networks and Trajectories of Adolescent Tobacco Use." *Addictive Behaviors* 35:678-385.

Preston, S.H., A. Stokes, N.K. Mehta, and B. Cao. 2013. Projecting the effect of changes in smoking and obesity on future life expectancy in the United States. *Demography* 51:27-49.

Preston, S. H. and A. Stokes. 2011. "Contribution of Obesity to International Differences in Life Expectancy." *American Journal of Public Health* 101(11):2137-43.

Rende, Richard, Cheryl Slomkowski, Elizabeth Lloyd-Richardson and Raymond Niaura. 2005. "Sibling Effects on Substance use in Adolescence: Social Contagion and Genetic Relatedness." *Journal of Family Psychology* 19:611.

Rogers, R. G., R.A. Hummer and C.B. Nam. 2000. Living and Dying in the USA: Behavioral, Health, and Social Differentials in Adult Mortality. San Diego: Academic Press.

Satre, D.D. et al. 2007. Alcohol Consumption Medical Conditions, and Health Behavior in Older Adults. *American Journal of Health Behavior* 31(3):238-248.

Shalizi, C.R., & Thomas, A.C. 2011. Homophily and contagion are generically confounded in observational social network studies. *Sociological Methods & Research*, 40, 211-239.

Smith, K. P. and N. A. Christakis. 2008. "Social Networks and Health." *Annual Review of Sociology* 34:405-29.

Thombs, D. L. and M. J. Hamilton. 2002. "Effects of a Social Norm Feedback Campaign on the Drinking Norms and Behavior of Division I Student-Athletes." *Journal of Drug Education* 32(3):227-44.

van den Bree, M. B. M., M. D. Whitmer and W. B. Pickworth. 2004. "Predictors of Smoking Development in a Population-Based Sample of Adolescents: A Prospective Study." *Journal of Adolescent Health* 35(3):172-81.

Wang, W.C. et al. 2012. Similar but different: Health behavior pathways differ between men and women. *Appetite* 58:760-766.

Warren, C. W., N. R. Jones, M. P. Eriksen, S. Asma and Gtss Collaborative Grp. 2006. "Patterns of Global Tobacco Use in Young People and Implications for Future Chronic Disease Burden in Adults." *Lancet* 367(9512):749-53.

Weitzman, E. R. and Y. Y. Chen. 2005. "The Co-Occurrence of Smoking and Drinking among Young Adults in College: National Survey Results from the United States." *Drug and Alcohol Dependence* 80(3):377-86.

Yang, S. M., J. Lynch, J. Schulenberg, A. V. D. Roux and T. Raghunathan. 2008. "Emergence of Socioeconomic Inequalities in Smoking and Overweight and Obesity in Early Adulthood: The National Longitudinal Study of Adolescent Health." *American Journal of Public Health* 98(3):468-77.