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Adam Fletcher, Chris Bonell, Annik Sorhaindo

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Title: You are what your friends eat: systematic review of social network analyses of young people's eating behaviours and bodyweight.

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Authors: Adam Fletcher PhD, Chris Bonell PhD, Annik Sorhaindo MSc

Authors' affiliations and contact details:

Dr. Adam Fletcher (corresponding author), Faculty of Public Health & Policy, London School of Hygiene & Tropical Medicine, Keppel Street, London WC1E 7HT, UK

Email: adam.fletcher@lshtm.ac.uk Tel: 020 7958 8312 Fax: 020 7580 4524

Dr. Chris Bonell, Faculty of Public Health & Policy, London School of Hygiene & Tropical Medicine, Keppel Street, London WC1E 7HT, UK

Annik Sorhaindo, Faculty of Public Health & Policy, London School of Hygiene & Tropical Medicine, Keppel Street, London WC1E 7HT, UK

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You are what your friends eat: systematic review of social network analyses of young people's eating behaviours and bodyweight.

ABSTRACT

Background: This review synthesises evidence regarding associations between young people's social networks and their eating behaviours/bodyweight and also explores how these vary according to the setting and sample characteristics.

Methods: Systematic review of cross-sectional and longitudinal observational studies examining the association between measures of young people's social networks based on socio-metric data and eating behaviours (including calorific intake) and/or bodyweight.

Results: There is consistent evidence that school friends are significantly similar in terms of their BMI, and friends with the highest BMI appear to be most similar. Overweight youth are also less likely to be popular and more likely to be socially isolated at school. Frequency of fast food consumption has also been found to cluster within groups of boys, as have body image concerns, dieting and eating disorders among girls.

Conclusion: School friendships may be critical in shaping young people's eating behaviours and bodyweight and/or vice versa, and suggests the potential of social-network-based health promotion interventions in schools. Further longitudinal research is needed to examine the processes via which this clustering occurs, how it varies according to school context, and the effects of non-school networks.

Keywords: Adolescent; Social Networks; Obesity; Eating Disorders; Review. [MeSH terms]

BACKGROUND

In high-income countries, obesity among children and young people has increased rapidly since the latter part of the twentieth century.[1] For example, a third of children and young people in the USA are considered to be overweight or obese, and prevalence is now also as high as 35% in parts of Europe with rates of increase accelerating worldwide.[2] In addition to the long-term health risks associated with obesity in adulthood, obesity is associated with type-2 diabetes among children and adolescents, and overweight adolescents have higher rates of depressive symptoms and lower self-esteem.[3] Conversely, trends in young people's dieting/weight-control behaviours and eating disorders are also of public health concern: 2-3% of adolescent females are thought to have a clinical eating disorder.[4] These young people are at risk of long-term physical harms and early mortality due to vitamin deficiencies and rapid weight loss.[5] Recognition of these trends and harms has led to an increasing emphasis on prevention and early intervention, and a need to understand better the determinants of such problems.[6-8] Social network analysis is one approach, examining the influence of social relationships on these outcomes.

Sociometric studies examine social relationships in terms of *nodes* (individuals) and *ties* (relationships), drawing on reciprocal reports from each individual in a putative tie. Network analysis based on these socio-metric data allows examination of how an individual's relationships and the characteristics of the broader social network are associated with, and can influence, outcomes. Such analyses can overcome problems with earlier studies of peer effects

on health-related behaviours which only examined immediate friendships rather than the wider peer group [9] and also generally relied on data from a single informant's reports of others' actions, which tends to over-estimate both the reciprocity of ties and the sharing of friends' behaviours and characteristics.[10]

Recent longitudinal studies of adults' social networks suggests that both obesity and eating disorders diffuse through social ties and may be 'socially contagious'. [11, 12] Although these studies focus on adults not young people, theoretical models to understand body-image concern and eating disorders have included peers as an important socio-cultural determinant [e.g. 13] and empirical studies report that young people perceive their close friends and peers to influence their eating behaviours. [14-17]

This suggests social networks may influence young people's eating behaviours and adolescent bodyweight as they do in adults. However, the evidence regarding associations and causal influences between young people's social networks, and eating behaviours, caloric intake and/or bodyweight has not been synthesized. Determining whether social networks causally influence these outcomes requires more than evidence of association.[11] As well as peer influence, associations may reflect reverse causality, whereby young people *select* friends as based on *shared behaviours* and/or bodyweight (homophily)[18], or confounding due to *structural equivalence*, whereby friends share characteristics other than their peer group which shape their eating behaviours and weight, such as family income and neighbourhood context.[19]

This systematic review aimed to examine whether: (1) there are associations between measures of *individual social position* (e.g. popularity) or a *measure of the overall structure of social networks* (e.g. density) and young people's eating behaviours, calorific intake and/or bodyweight; and (2) explore how these associations vary according to the setting and participants' socio-demographic characteristics. To do this we examined cross-sectional and longitudinal studies based on analyses of socio-metric data. Although longitudinal data is needed to examine the direction of potential network effects and processes over time, cross-sectional studies can provide further evidence regarding the nature and extent of associations, informing further research and new interventions.[20]

METHODS

Search strategy

Major bibliographic databases (Social Science Citation Index, PubMed) and specialist registers (ADOLESC, ERIC) were searched in March 2009 using appropriate free-text and thesaurus terms relating to the population (e.g. "adolescent" or "youth"), social networks (e.g. "network" or "peer group") and health-related outcomes (e.g. "diet" or "obesity"). A full list of terms is available on request. Keywords, titles and abstracts were then screened according to the inclusion criteria specified below. The bibliographies of included studies were also searched and

key investigators were contacted to identify 'grey literature', PhD thesis and forthcoming publications.

Inclusion criteria

There were no restrictions according to language or publication date. Cross-sectional and longitudinal observational studies examining the association between measures of young people's social networks based on reciprocal socio-metric data and eating behaviours or bodyweight were identified, including studies of dyadic relationships nested within larger sociometric datasets. Those studies which described non-reciprocal ego-centric reports of relations were not included. Studies were therefore eligible for inclusion if they:

(a) collected 'reciprocal' data from a defined group of young people in the age range 11-18 in order to be able to describe the pattern and/or nature of friendship connections (ties) between individual young people (nodes);

(b) provided summaries of social-network characteristics at the level of the individual (e.g. popularity) or network (e.g. density);

(c) reported on measures of eating-related behaviours, caloric intake or bodyweight at the individual or network level; and

(d) reported one or more measures of association between (b) and (c).

Data extraction and synthesis

A standardised framework was used by two independent reviewers to extract data from studies (available on request). Neither outcomes nor summaries of social-network characteristics were sufficiently homogenous to undertake statistical meta-analysis and therefore findings are synthesised narratively.

RESULTS

After screening 2,242 titles and abstracts, we identified ten studies (published between 1995 and 2010) which met our inclusion criteria. All of these focused on school social networks and five used data collected in the *US National Longitudinal Study of Adolescent Health (Add Health)* surveys (but undertook different analyses of these data).[21-25] A further two were based on other US studies [26, 27] and three used social network data collected in Australian high schools.[28-30]

Sample sizes ranged from 385 to 17,557 school students (see **Table 1** for further details of study design, sample size and characteristics, methods for collecting and analysing social network data, and key findings reported by authors). Three studies reported on longitudinal data,[22-24] while seven drew on cross-sectional data. One study reported only on associations between

individual-level measures of young people's school social networks – such as the number of nominations received/given (in-degree/out-degree), reciprocity, and centrality – and bodyweight.[21] Eight used sociometric data to examine network-level associations with eating behaviours/bodyweight.[23-30] Two of these also reported analyses of *individual-level* measures of young people's school social networks.[24, 27] One study also reported associations among dyads constructed within the Add Health dataset.[22]

The studies reported on a range of outcome measures. One examined high calorie food consumption.[30] Eight studies examined body mass index (BMI), used to define 'healthy', overweight, obese and underweight individuals.[21-25, 27-29] Two examined dieting, extreme weight-loss behaviours, binge eating and body-image concern as well as BMI score.[28, 29] One focused on bulimic symptoms.[26]

School social networks and high calorie food consumption

One cross-sectional study focused on secondary school students' high calorie food consumption and found that male friends were significantly alike in their consumption of fast food but no similarities were identified between girls' friends and fast food consumption, or other measures of high calorie food consumption (e.g. high calorie drink consumption).[30]

Table 1: Summary of included studies (N=10)

Study	Country	Study design	Sample size and characteristics	Data collection methods	Method(s) for collecting and summarising social network data	Method(s) for analysing social network data	Eating behaviour and/or bodyweight measures	Key findings
<p>Cohen-Cole and Fletcher [22]</p> <p><i>National Longitudinal Study of Adolescent Health (Add Health)</i></p>	USA	Longitudinal	<p><u>Schools</u> N/S</p> <p><u>Students</u> N=1988</p>	School-based and in-home surveys.	<p>Respondents asked to list up to 10 of their closest friends (5 males, 5 females).</p> <p>Dyads constructed based on 'first friend named' by each subject</p>	Logistic and OLS regression	Obesity	<p><i>Odds that an ego becomes obese if his or her 'best friend' is obese:</i></p> <p>Unadjusted = <u>0.8</u></p> <p>After adjusting for school-specific trends = <u>0.51</u></p> <p>After adjusting for school-specific trends <i>and</i> individual fixed effects = no-sig. effect</p>
<p>de la Haye et al [30]</p>	Australia	Cross-sectional	<p><u>Schools</u> N = 2</p> <p><u>Students</u> N = 385</p> <p>Age = 13-15 Male = 202 Female = 183</p>	School-based survey.	<p>Respondents listed the first and last names of all their "close friends" in their school grade (defined as friends they "hang around with" most).</p>	Exponential Random Graph Modelling, stratified by gender.	High-calorie food consumption (fast food, savoury snack foods, sweet snack foods, high calorie drinks).	<p>Girls <u>No significant within-group similarity</u></p> <p>Boys</p> <p>Fast Food Consumption <i>Significant within-group similarity in 2/3 Networks (Model Parameter Estimates for Absolute Difference Effects = -0.08 – -0.12)</i></p> <p>Sweet Snack Food Consumption <i>Significant within-group differences in 1/3 Networks (Model Parameter Estimates for Absolute Difference Effects = 0.16)</i></p> <p>Savoury Snack Food Consumption <i>No significant differences</i></p> <p>High Calorie Drink Consumption <i>No significant differences</i></p>

<p>Fowler and Christakis [23]</p> <p><i>Add Health</i></p>	<p>USA</p>	<p>Longitudinal</p>	<p><u>Schools</u> N/S</p> <p><u>Students</u> N=1988</p>	<p>School-based and in-home surveys.</p>	<p>Respondents asked to list up to 10 of their closest friends (5 males, 5 females).</p>	<p>Logistic regression</p>	<p>Obesity</p>	<p><i>Ego becomes obese if his or her 'best friend' is obese after adjusting for school-specific trends</i> (coef. 0.033, S.E. 0.014, P=0.020)</p> <p>Evidence of 'directional effects' (i.e. influence): 'Named friends' not influenced by 'namers' (P=0.90)</p>
<p>Halliday and Kwak [25]</p> <p><i>Add Health</i></p>	<p>USA</p>	<p>Longitudinal</p>	<p><u>Schools</u> N = 16</p> <p><u>Students</u> <i>Wave 1</i> N = 4617 <i>Wave 2</i> N = 2970</p> <p>Mean age = 15 Male = 48% Female = 52%</p> <p><i>Ethnicity</i> White 55% Black 19% Asian 12%</p> <p><i>SES</i> Single parent household ~ 30%</p>	<p>School-based and in-home surveys.</p>	<p>Respondents asked to list up to 10 of their closest friends (5 males, 5 females).</p>	<p>Logistic regression (school fixed effects)</p>	<p>BMI</p> <p>Overweight (BMI at or above 85th percentile)</p> <p>Underweight (BMI below the 10th percentile)</p>	<p>Correlations between own BMI and average peer BMI</p> <p>BMI <u>Girls</u> <i>10 point increase in friend BMI associated with 1.9 increase in own BMI</i></p> <p><u>Boys</u> <i>10 point increase in friend BMI associated with 1.8 increase in own BMI</i></p> <p>Overweight <u>Girls</u> <i>10% increase in friends' propensity to be overweight is associated with 1.1% increase in own propensity to be overweight</i></p> <p><u>Boys</u> <i>10% increase in friends' propensity to be overweight is associated with 0.8% increase in own propensity to be overweight</i></p> <p>Underweight No correlation</p> <hr/> <p>Determinants of changes in own BMI</p> <p><i>Adolescent who nominate overweight friends at Wave 1 most likely to gain weight by Wave 2.</i></p>

<p>Hutchinson and Rapee [29]</p>	<p>Australia</p>	<p>Cross-sectional</p>	<p><u>Schools</u> N = 10</p> <p><u>Students</u> N = 1094</p> <p>Mean age = 12.3 Female = 100%</p> <p>SES 84% born in Aus. 83% Eng. 1st lang. 82% 2-parent family</p>	<p>School-based survey.</p>	<p>Respondents asked to identify friends who they spend most time with at school from the Grade 7 roster.</p> <p>Friendship cliques (N = 173) identified using UCINET software.</p>	<p>Multivariate analyses of covariance (MANCOVA) within friendship cliques.</p>	<p>BMI</p> <p>Dieting</p> <p>Extreme weight loss behaviours</p> <p>Binge eating</p> <p>Body image concern</p>	<p>BMI <i>Significant within-group similarity (effect size = 1.69; p = 0.000)</i></p> <p>Dieting <i>Significant within-group similarity (effect size = 0.26; p = 0.001)</i></p> <p>Extreme weight loss behaviours <i>Significant within-group similarity (effect size = 0.27; p = 0.020)</i></p> <p>Binge eating <i>Significant within-group similarity (effect size = 0.24; p = 0.026)</i></p> <p>Body image concern <i>No significant differences</i></p>
<p>Paxton et al [28]</p>	<p>Australia</p>	<p>Cross-sectional</p>	<p><u>Schools</u> N = 6</p> <p><u>Students</u> N = 523</p> <p>Age = 15-16 Female = 100%</p>	<p>School-based survey.</p>	<p>Respondents asked to identify girls who they spend most time with at school from the Grade 10 roster.</p> <p>Friendship cliques (N = 79) identified using UCINET software.</p>	<p>Multivariate analyses of covariance (MANCOVA) within and between friendship cliques</p> <p>Hierarchical regression models of friendship variables.</p>	<p>BMI</p> <p>Body image concerns</p> <p>Dieting</p> <p>Extreme weight loss</p> <p>Binge-eating</p>	<p><i>Intra- versus inter-clique variability</i></p> <p>BMI <i>Significantly higher between- than within-group variance</i></p> <p>Body image concerns <i>Significantly higher between- than within-group variance (p=.002)</i></p> <p>Dieting <i>Significantly higher between- than within-group variance (p=.024)</i></p> <p>Extreme weight loss <i>Significantly higher between- than within-group variance (p=.001)</i></p> <p>Binge-eating <i>No significant differences</i></p> <hr/> <p><i>Friendship variables predicted:</i> *14% variance in body image concerns *14% variance in dietary restraint</p>

								<p>*12% variance in extreme weight-loss behaviours *12% variance in binge eating disorders.</p>
Pike [26]	USA	Cross-sectional	<p><u>Schools</u> N = 3</p> <p><u>Students</u> N = 410</p> <p>Mean age = 16 Age range = 14-19 Female = 100%</p>	School-based survey.	<p>Respondents asked to identify up to six of her closest female friends.</p>	<p>Girls were considered part of an individual's friendship network if they reciprocated the nomination of friendship.</p> <p>Hierarchical regression modelling, stratified by grade.</p>	<p>Bulimic Symptoms</p>	<p><i>Bulimic symptoms were predicted by:</i></p> <p>Bulimic symptoms in the friendship network (OR = 1.29; p < 0.0001)</p> <p>Rate of anorexia or bulimia among friends (OR = 0.12; 0.0001)</p> <p><i>Within-network similarities varied by grade</i></p> <p>Positively association at 9th grade Negatively association at 12th grade.</p>
<p>Strauss and Pollack [21]</p> <p><i>Add Health</i></p>	USA	Cross-sectional	<p><u>Students</u> N = 17,557</p> <p>Students 7th – 12th Grade</p> <p>BME African Am.18% Hispanic 12%</p> <p>SES Single parent household = 29%</p>	School-based and in-home surveys.	<p>Respondents asked to list up to 10 of their closest friends (5 males, 5 females).</p> <p>Friendship networks were generated using PAJEK and SAS IML software.</p>	Multivariate regression analysis	<p>Overweight (BMI above 95th percentile)</p>	<p><i>In-degree (mean no. of nominations)</i></p> <p><u>Girls</u> 3.41 overweight vs. 5.01 normal-weight; P < 0.001</p> <p><u>Boys</u> 3.38 overweight vs. 4.55 normal-weight; P < 0.001</p> <p><i>Popularity (5 ≤ nominations)</i></p> <p><u>Girls</u> 27% overweight vs. 47% normal-weight; P < 0.001</p> <p><u>Boys</u> 28% overweight vs. 40% normal-weight; P < 0.001</p> <p><i>Reciprocity -- Best male friend nominates as best friend</i></p> <p><u>Girls</u> 12% overweight vs. 29% normal-weight; P < 0.002</p> <p><u>Boys</u></p>

								<p>31% overweight vs. 34% normal-weight; P = 0.3</p> <p>Reciprocity -- Best female friend nominates as best friend</p> <p><u>Girls</u> 34% overweight vs. 46% normal-weight; P = 0.002</p> <p><u>Boys</u> 18% overweight vs. 24% normal-weight; P = 0.049</p> <p>Centrality (mean Bonacich score)</p> <p><u>Girls</u> 0.53 overweight vs. 0.78 normal-weight; P < 0.001</p> <p><u>Boys</u> 0.54 overweight vs. 0.69 normal-weight; P < 0.001</p> <p>Social isolation (no nominations) Overweight OR = 1.71 (CI 1.39-2.20)</p>
<p>Trogdon et al [24]</p> <p><i>Add Health</i></p>	USA	Cross-sectional	<p><u>Schools</u> N = 16</p> <p><u>Students</u> N = 3702</p> <p>Mean age = 16.1</p>	School-based and in-home surveys.	Respondents asked to list up to 10 of their closest friends (5 males, 5 females).	Multivariate regression analysis	<p>BMI</p> <p>Overweight (BMI at or above 85th percentile)</p>	<p>Friendship nominations Overweight adolescents less likely to be nominated as a friend</p> <p>Influence of friends' weight Mean weight among friends positively associated with adolescent weight (OLS 0.30; p < 0.001)</p> <p>Influence of grade-level peers' weight Mean weight among grade-level peers positively associated with adolescent weight (OLS 0.23; p < 0.005)</p>
<p>Valente et al [27]</p>	USA	Cross-sectional	<p><u>Schools</u> N = 4</p> <p><u>Students</u> N = 617</p>	School-based survey.	Respondents asked to nominate friends in her class.	Random-effect logistic regression modelling, with individuals	<p>Overweight (BMI above 95th percentile)</p>	<p>Girls</p> <p>Friends' average BMI Positive association with being overweight</p>

			<p>Age = 11-15</p> <p>Male = 36% Female= 64%</p> <p><i>Ethnicity</i> Asian 36% Hispanic 30% White 12% Mixed 12% Other 6% African-Am. 3%</p>			nested by school-class	<p><i>Number of friends named</i> Positive association with being overweight (OR 1.57; CI 1.01 – 2.46)</p> <p><i>Frequency named as a friend</i> Negative association with being overweight for girls (OR 0.89; CI 0.75 – 1.07).</p> <hr/> <p>Boys</p> <p><i>Friends' average BMI</i> Positive association with being overweight</p> <p><i>Number of friends named</i> No association with being overweight</p> <p><i>Frequency named as a friend</i> No association with being overweight</p>
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School social networks, BMI and obesity

All eight studies which used body mass index (BMI) scores to calculate bodyweight and/or identify overweight and underweight individuals found evidence that school friends tend to be similar in terms of their BMI.[21-25, 27-29] Five of these studies were based on analyses of Add Health surveys, which include questions about friendship networks and height/weight.[21-25]

Trogon and colleagues' cross-sectional analyses of the Add Health data found that friends' BMI is positively associated with a student's own BMI. When an adolescent's friend's mean BMI is 1 unit higher (approximately 6 pounds for a 16-year-old of average height), the adolescent's own weight is higher by 0.3 BMI units (approximately 2 pounds for a 16-year-old of average height).[24] These associations were strongest among those young people at the higher end of the BMI spectrum (i.e. overweight). Similarly, Valente and colleagues analysed cross-sectional data collected in four schools in the Los Angeles area and found that overweight youth were twice as likely to have overweight friends.[27]

Drawing on longitudinal data from two waves of the Add Health surveys, Halliday and Kwak also found that friends' average BMI was positively associated with a student's own BMI at follow-up, and that those students who have friends who are overweight are also more likely to subsequently become overweight themselves.[25] This suggests the importance of social influence. Fowler and Christakis similarly found that risk of becoming obese increased when friends were obese, even after controlling for overall school trends.[25] Further support for the

idea of *social influence* comes from Fowler and Christakis finding that non-reciprocal 'named friends' were *not* influenced by 'namers' over time.[25]

Conversely, Cohen-Cole and Fletcher suggest that observed similarities in friends BMI over time in the Add Health study are explained by *homophily*. [22] They constructed friendship dyads based on the first friend named by respondents in the Add Health survey and found that, after controlling for potential confounding due to shared school environment, the odds that an ego becomes obese increase by 51% if his or her 'alter' (friend) was also obese.[22] After controlling for both contextual factors and individual-level 'fixed effects' the relationship between friendship dyads and BMI disappeared, which the authors suggest indicates that young people *select* friends similar to themselves.

Trogdon and colleagues found that overweight adolescents were less likely to be nominated as a friend,[24] as did Strauss and Pollack who studied overweight students' social position and report that for all network measures overweight adolescents were more likely to receive no or few friendship nominations and report fewer reciprocal friendships.[21] After adjusting for socio-demographic factors, participation in physical activity and clustering by school, the average 'social penalty' was minus 1.25 friendship nominations for girls and minus 1.03 for boys ($p < 0.001$). While Valente and colleagues found that overweight girls were less likely to be named as a friend, there was no such association among boys.[27]

At the network level, the two Australian cross-sectional studies suggests that female high-schools students' friendship groups resemble each other with respect to BMI scores, and that differences in BMI are significantly greater *between* rather than within friendship groups.[28, 29]

School social networks, body image concerns and eating disorders

There is evidence that among girls behaviours such as dieting and extreme weight loss behaviours are clustered in certain groups within schools. In a cross-sectional US study, Pike found that bulimic symptoms were strongly predicted by having female high-school friends who also reported bulimic symptoms [26], while Hutchinson and Rapee also found significant within-group similarity regarding students' dieting, extreme weight loss behaviours and binge eating among girls at Australian high schools, even after controlling for BMI, self-esteem and 'negative' emotions. Around 25% of the variance in these behaviours could be explained by group membership.[29] Friendship groups which reported high levels of dieting and extreme weight loss behaviours were also associated with high mean group reports of: friends' concern with thinness and dieting; peer pressure to lose weight and to be thin; and, peer teasing.[29]

In contrast, another cross-sectional study of female high school students in Australia by Paxton and colleagues found that friendship groups among girls in Australian high schools shared similar levels of body image concern, dietary restraint and, use of extreme weight loss behaviours after adjusting for individual physical and psychological factors,[28] However, within

this sample, binge eating was not associated with social network once individual-level socio-demographic and physical factors were included in multivariate analysis. Further analyses suggested that perceptions of friends' views and actions with respect to body image concern and dieting, and the extent to which a student reported comparing her body with others, were influential in these behaviours clustering.[28]

How do these associations vary according to the setting and socio-demographic characteristics?

The study by de le Haye and colleagues only found associations between boys' friendship groups and fast-food consumption within *two out of three school networks*.[30] Within one network the consumption of fast food was positively associated with popularity (receiving nominations), suggesting that the underlying social processes may vary across different school cultures and contexts. Although fast-food consumption appeared to cluster among groups of male school-friends, both the propensity to be overweight when friends were overweight and the risk of social isolation due to being overweight appeared to be greatest among females.[21, 22, 27] There is also some evidence that the importance of friendships on having eating disorders might be greatest in early adolescence, for example among 12-14 year olds, and this diminishes later in females' high school careers.[26]

DISCUSSION

The evidence reviewed above suggests that, in high-income countries, school friendships may be critical in shaping young people's eating behaviours and bodyweight and/or vice versa. There is consistent evidence that school friends are significantly similar in terms of their BMI, and adolescents with the highest BMI appear to be most similar. Overweight youth are also less likely to be popular students and are at risk of being socially isolated at school. Frequency of fast-food consumption has also been found to cluster within groups of boys, as have body image concerns, dieting and eating disorders among girls.

Although there is consistent evidence about associations, the studies reviewed do not provide definitive evidence about the relative importance of peer influence, peer selection, and structural equivalence/confounding. It is plausible that all three occur and partly explain the patterns reported. There is some evidence that peer influence may underlie diffusion of obesity [23, 25] and eating disorders[28, 29], and that homophily may explain observed similarities in friends BMI over time.[22] Although structural equivalence may partly explain within-group similarities, these may decline once potential confounders, such as school environment, are adjusted for. However, none of the studies found that such external, shared characteristics fully explained significant relationships between students' social networks, on the one hand, and their eating behaviours or bodyweight, on the other.

Limitations

Only a limited number of studies were identified (n=10), all of which drew on data from the USA or Australia, so that these findings may not be generalizable elsewhere. Furthermore, the majority were cross-sectional and cannot determine causal direction. The three longitudinal studies drew different conclusions due to their different methodological approaches.[22, 23] Furthermore, Cohen-Cole and Fletcher's findings are limited because they only use friendship dyads (rather than all observed friendships) that are static over time, which leaves students' 'random' ex-friends in the model and thus reduces the chance of finding any effects due to friendship.[22]

Although all the included studies aimed to control for confounding by age, gender, ethnicity and/or socio-economic status, there may have been residual confounding from factors such as parenting styles or baseline non-health risk behaviours. However, *over-adjustment* is also a potential limitation, and some studies may therefore have *under-estimated* the true association between students' social networks and eating behaviours/bodyweight. For example, Hutchinson and Rapee report that around 25% of the variance in the eating behaviours they studied could be explained by group membership after controlling for individuals' BMI, self-esteem and 'negative' emotions [29], although factors such as self-esteem may lie on the causal pathway. More generally, the statistical methods applied in the field of social network analysis are constantly evolving, and results may differ according to the whether logistic regression models or ERGM is applied.[27, 30]

All these analyses examined young people's social networks *in school*, ignoring out-of-school friendships which may be influential.[32] While schools provide a unique institutional context in which to collect and construct 'complete' (rather than 'ego-centric') network data,[31] young people have other peer groups and different friends outside school so the identified networks are incomplete.[32] For example, other friends who live in the same neighbourhood but go to different school, or have left school, could be influential in determining eating behaviours. A further limitation with the studies identified is that they do not examine how a school or community's macro-social network structure can influence aggregate health outcomes over and above the effects of friendship networks. For example, do schools with *denser networks* and/or larger components facilitate the *diffusion* of obesity or 'crash' dieting?

Finally, a limitation of all systematic reviews is their reliance on authors' descriptions of the methods and exposures under study, and how the findings are presented in published reports and papers. For example, authors do not always define concepts such as obesity in exactly the same way or report how they measured this. Furthermore, measures of effect sizes were reported inconsistently across studies, and in some cases the effect sizes were not reported. It is also important to note that in some cases multiple tests of significance within papers may have resulted in some apparent associations having arisen due to chance.

Implications for policy and practice

Youth is a period of dramatic physical, cognitive, social and emotional development and offers health promoters a special opportunity to encourage healthy lifestyles. Although peer education has been widely used to address adolescent substance use and sexual health [33, 34], school-based peer education addressing young people's eating behaviours and bodyweight has received relatively little attention. Interventions addressing parental influences, food prices and marketing, and school nutrition policies continue to receive greatest attention and investment.[8] The evidence synthesised here suggests the potential of social-network-based health promotion interventions in schools. One such intervention is the AHEAD project, an intervention which aims to promote healthy eating via the ASSIST model of peer education and positive influence [34], currently being piloted by researchers at Bristol University.

There may also be scope for developing peer-group-based counselling and motivational interviewing interventions targeting those groups of young women most at risk of eating disorders in a supportive, non-stigmatising group-setting. It would also be appropriate to pilot interventions aiming to support overweight students in making new friendships in school in order to avoid isolation or confinement to *obesogenic cliques*.

Furthermore, if school friendships *are* influential in determining young people's eating behaviours and bodyweight, then interventions such as those above could have a social 'multiplier' effect [35] whereby their initial impact spreads more widely via social diffusion. This would, in turn, imply that those school-based interventions which have previously been found

to be effective, such as whole-school healthy eating programmes [36], may have a greater 'reach', wider benefits, and be more cost-effective than previously thought.

Implications for research

Well-conducted longitudinal studies are necessary to determine the relative importance of selection, influence and structural equivalence. Such studies need to occur in a wider range of contexts, and in countries other than the USA and Australia, and should also aim to capture non-school friends via community and on-line surveys. Future studies should also examine the effects of macro- as well as micro-social networks, and the processes through which any effects occur (e.g. through the establishment of BMI norms and a reference for body image).

Additionally, little attention has been paid to how and why social-network influences can vary according to contextual and socio-demographic characteristics and this should be a priority for future analyses of social network studies of young people's eating and weight. For example, does the relative importance of selection versus influence vary according to *school context*, and if so how? Qualitative studies are also needed to understand the meaning and importance of network structures within school hierarchies [37], and explore how school-environmental factors vary, such as the canteen peer-group environment.[38] Finally, the current evidence ignores peer group influences on eating disorders among boys, despite increasing concerns [39], who could also be subject of future social network studies on the issue.

CONCLUSION

Social network analysis is a rapidly emerging area within the research on adolescent eating behaviours and bodyweight, with seven out of the ten studies in this review published since 2007. In the field of public health, network analysis can be applied to understand how social relationships determine health-related knowledge, attitudes and behaviours and to inform new health promotion interventions.[20] There is consistent evidence that school friends are significantly similar in terms of their eating behaviours and bodyweight, particularly the most overweight young people. Further longitudinal research is needed to examine the processes via which this clustering occurs, and how it varies according to school context. There is also scope for health promoters to pilot and evaluate social-network-based health promotion interventions in schools to promote healthy eating and reduce body image concerns.

What is already known on this subject?

Recent evidence suggests that obesity and eating disorders can spread via social networks.

Various theories and empirical studies suggest young people's friends may influence their eating behaviours, bodyweight and body image concerns.

No systematic review has synthesized the evidence about the association of young people's social networks and eating behaviours or bodyweight, and whether associations reflect influence, selection or confounding.

What does this study add?

There is consistent evidence that school friends are significantly similar in terms of eating behaviours and body mass index (BMI), with the strongest associations for BMI found among the most overweight. Eating disorders have also been found to cluster within groups of female friends. Overweight youth are less likely to be popular and more likely to be socially isolated at school.

This evidence suggests the potential of social-network-based health promotion interventions in schools to complement existing school-based initiatives addressing young people's diet.

The relative importance of influence, selection and confounding is uncertain because of the inconsistency of findings from the small number of longitudinal studies.

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Conflict of interest statement

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