Published in final edited form as:

Appl Health Econ Health Policy. 2014 April ; 12(2): 191–201. doi:10.1007/s40258-014-0084-y.

That's What Friends Are For: Adolescent Peer Social Status, Health-Related Quality of Life and Health-Care Costs

Marlon P. Mundt¹ and Larissa I. Zakletskaia¹

¹University of Wisconsin School of Medicine and Public Health

Abstract

Background—Social connections at all stages of life are essential for physical and mental well-being. Of particular importance are social relationships during adolescence that shape adult health behaviors and health outcomes.

Objective—The aim of the study was to estimate the association between adolescent peer status in school and later life quality-adjusted life years (QALYs) and health-care costs.

Methods—This study used social network and health outcomes data from Wave I (ages 12–18 years) and Wave III (ages 18–24 years) of the US National Longitudinal Study of Adolescent Health ($n = 10\,578$) to compare QALYs and health-care costs (in 2012 US\$) by adolescent peer status in US schools. Generalized linear models controlled for school fixed effects, individual and family characteristics, and US census block neighborhood effects. Non-parametric bootstrapping accounted for residual skewness in QALYs and health-care costs. Net monetary benefit was calculated by converting adjusted 5-year QALYs into US\$ values and subtracting 5-year health-care costs. Net monetary benefit was then compared across quintiles of adolescent peer status in school at Wave I.

Results—Results obtained from non-parametric bootstrapping indicate that adolescents with higher peer status in school experience significantly better health and lower health-care costs over the next 5 years. At US\$50 000 per QALY, adolescents with 8 or more friends achieved net monetary benefit of US\$214 300 (95% CI 212 800, 215 800) over a 5-year span, in comparison to adolescents with 0–1 friends, who attained US\$209 900 (95% CI 207 900, 211 700) net monetary benefit. This difference translates into roughly US\$4440 (95% CI 2036, 6825) per socially disengaged adolescent in additional health costs and/or reduced QALYs over 5 years.

Conclusion—The study calls for randomized controlled trials targeting adolescent peer group structures in schools as a means to promote better health and lower health-care costs in adulthood.

1. Introduction

Social connections at all stages of life are essential for physical and mental well-being [1–4]. Of particular importance are peer social relationships in adolescence that may shape adult health behaviors and health outcomes [5–11].

Corresponding author: Marlon P. Mundt, University of Wisconsin School of Medicine and Public Health, Department of Family Medicine, 1100 Delaplaine Ct., Madison, WI 53715 marlon.mundt@fammed.wisc.edu.

Author contributions Marlon Mundt designed the study, conducted the statistical analyses and took the lead on writing the manuscript. Larissa Zakletskaia contributed to study design, interpretation of results, and made substantive contributions to the writing and revision of the manuscript. Marlon Mundt acts as guarantor of the content.

Conflicts of interest Marlon Mundt was supported by a grant from the National Institute on Alcohol Abuse and Alcoholism, NIAAA 1K01 AA018410-01, to conduct this analysis. The authors declare no conflicts of interest.

Research shows that peer status at school, where adolescents spend most of their waking hours, interacting with peers on a daily basis, has lasting health implications [12]. Peer status reflects the degree to which an adolescent is accepted, integrated and respected in school. It also includes esteem, visibility, and reputation among classmates. Peer status refers not just to likability among peers, but also to power and influence in the classroom. Adolescent peer status is often measured as the frequency with which one is nominated as a friend by one's school peers [13]. Peer status measured through friendship nomination depends less upon individual judgments than on consensual group agreement in the school.

A substantial body of cross-sectional evidence demonstrates that adolescent peer status is associated with health outcomes and health behaviors [8, 14-17]. In one study, 11- to 15-year olds who indicated high peer status were twice as likely to report good self-rated health as low peer status adolescents [14]. Conversely, poor peer status is associated with a 2 ½-fold increase in self-reported musculoskeletal pain among teenagers [16] and depressive symptoms in early adolescence [8].

In addition, several prospective longitudinal cohort studies link peer status in adolescence with adult health outcomes. Adolescents (aged 8-12 years) with higher peer status in school reported better health as adults (aged 45-52 years) than adolescents with lower peer status [7]. This association could not be explained by socioeconomic and individual childhood characteristics. Students with low peer status in sixth grade were more likely to suffer from adult illness (e.g., cardiovascular disease and diabetes) and mental health disorders (e.g., depression, anxiety, alcohol abuse, and dependence) [5]. This finding also could not be fully explained by parental socioeconomic class.

Furthermore, adolescent peer status is associated with the use of health-care [12, 18, 19]. Adolescents with no close friends had more hospitalizations in adulthood than adolescents who had at least one friend [12]. Anxiety and depression among adolescents, frequently associated with poor peer status, were linked to greater pediatric health-care utilization and costs [19].

Because adolescent peer status could not be randomized, determining here, as in any study, the direction of causality requires careful consideration. However, an extensive body of evidence suggests that peer status precedes health effects. Research suggests that episodes of acute illness have little to no effect on adolescent peer status [20]. Depression prospectively did not lead to low peer status among adolescents, but peer rejection predicted depression [21]. Similarly, intervention students who increased the number of peer friendship nominations in a randomized controlled trial of a kindness curriculum in school classrooms also experienced increased life satisfaction and positive affect compared to control students [22]. Furthermore, when adolescent friendship nominations were more evenly distributed across students, students in the classroom reported better well-being [8]. Notably, the adolescent peer status and health findings are in line with results in adults. A meta-analysis of 148 studies implicates social isolation and loneliness in greater mortality risk in adults than obesity, lack of physical activity, excessive alcohol consumption, or hypertension [3].

Adolescent peer status may impact long-term health through buffering of stress effects [23-25]. Research suggests that the link between adolescent peer status and subsequent health could operate through emotional and social support [24]. Adolescents have been shown to produce lower cortisol levels in response to a stressful event when a friend is present compared to when they are alone [26]. It is possible that lack of friendships in adolescence may lead to poor coping skills with stress and worse immune system responses in adulthood, which, in turn, could result in worse health outcomes and greater health-care costs.

Adolescent peer status may also influence later-life health through the psychological pathways of self-esteem and self-efficacy. Self-esteem and self-efficacy improve adaptation to stressful life events, encourage positive affect and protect against depression [21, 27, 28]. Adolescents may develop self-efficacy from one another through observation, imitation, and modeling of health behavior choices [29-31]. Greater peer status provides access to multiple sources of information that could help one make more informed health choices and avoid risky health behaviors [32, 33].

In contrast, low peer status may influence health by “getting under the skin” and increasing a biological “general susceptibility” to illness [5, 6, 34]. The biological mechanism between adolescent peer status and subsequent health may be a physical response to chronic stress, which may be mitigated by the presence of friends. The hypothalamic pituitary adrenal (HPA) axis relates social relationships, chronic stress and illness [24, 35-37]. Chronic stress leads to prolonged activation of the HPA-axis, which stimulates a cortisol response [38]. Extended cortisol activity is linked to increased cardiovascular disease, diabetes, cancer and reduced immune system response [39]. Chronic stress in children has been shown to add an additional six years to cell aging, as measured by the DNA marker telomere length [40].

While available research reveals the link between adolescent peer status and later-life health and health-care utilization, it is not enough for policy decision makers to uncover that such a link exists. It is essential to quantify the health outcomes and health-care utilization costs associated with peer status in school. In this study, we use a net monetary benefit approach [41] to test the relationship between adolescent peer status in school, health, and health-care costs later in life.

2. Methods

2.1 Data source

This study takes advantage of the unique social network and health outcomes data collected by the US National Longitudinal Study of Adolescent Health (Add Health). The study, using a nationally representative sample of US middle and high school students ages 12 to 18 years [42], allows the creation of peer status strata based on school social network characteristics.

Add Health used stratified sampling to enroll high schools that were representative of schools nationwide based on region of the country, urbanicity, school funding, and racial composition. The study enlisted corresponding middle-school and junior-high feeder schools for the participating high schools. Add Health was approved by the Institutional Review Board of the University of North Carolina-Chapel Hill.

All seventh- through twelfth-grade students at the 132 participating schools were invited to complete an in-school survey. Students who responded to the in-school survey ($n=90\,118$) were randomly selected for an in-home interview and parent survey (Wave I, $n=20\,745$). Wave I was conducted from April 1995 to December 1995. Researchers recontacted the original Wave I respondents for a Wave III survey between April 2001 and February 2002. At the time of the Wave III interview, participants ($n=15\,170$) were 18 to 24 years old.

2.2. Analytic sample

A total of 15 190 adolescents completed the Add Health Wave III survey. Of these, 4592 (30%) did not have Wave I school friendship data available and were excluded from the analysis. School social network data were not made available if a student's name was not present on the in-school friendship survey or if less than 50% of the students at the school completed the in-school friendship survey. The study sample was composed of 10 578 respondents to the Wave III survey for whom social network data were available at Wave I.

2.3. Measures

2.3.1. Peer status—In Wave I, study subjects listed up to 5 males and 5 females as friends from an all-school roster. Peer status was calculated as the number of friendship nominations received from the other school students (i.e. *in-degree*). The *in-degree* parameter is frequently used to measure peer status in adolescent school groups [10]. Subjects were divided into peer status quintiles based on their *in-degree*. The division of subjects into quintiles was based on the expectation that the relationship between peer status and health outcomes was most likely not linear. We expected that the marginal benefit of an additional friendship nomination would be greater for an adolescent with fewer friendship nominations than for an adolescent with many friendship nominations.

2.3.2. Quality-Adjusted Life Years (QALYs)—Quality-adjusted life years (QALYs) account for both health-related quality of life and its duration across various medical conditions [43-45]. QALYs serve as an important tool for comparison evaluation of health interventions.

QALYs over the past 5 years were computed based on physical function, medical conditions, and diagnoses reported at Wave III of Add Health, when subjects were 18 to 24 years old. Subjects reported if they had been diagnosed with asthma, depression, diabetes, hypertension, migraines, epilepsy, or cancer. They also indicated whether their health limited their mobility and self-care (Medical Outcomes Study PF-10 Physical Function Scale [46]), whether they had blindness in one or both eyes, and whether they suffered from hearing loss. The analysis calculated five-year QALYs for each individual subject by subtracting QALYs lost due to the reported medical conditions and health limitations from full health over the past 5 years (i.e., full health QALYs=5). Annual QALY loss values for chronic conditions (0.054 per chronic condition), blindness (0.050), and hearing loss (0.006) were derived from the Medical Expenditure Panel Survey (MEPS) based on average disutility reported in the literature [47, 48]. QALY loss values for mobility (0.146 for moderate impairment, 0.558 for severe impairment) and self-care limitations (0.175 for moderate limitation, 0.471 for severe limitation) were derived from preference-weighted disutility derived from a representative sample of the US population [49].

2.3.3. Health-Care Utilization Counts and Costs—At Wave III, participants reported the number of times they had been hospitalized or had visited the emergency room in the past 5 years, whether they had received inpatient treatment for a mental illness in the past 5 years and whether they had attended an alcohol and other drug abuse (AODA) treatment program in the past year. The analysis multiplied utilization counts by US\$ costs derived from the 2004 MEPS [50] and adjusted to 2012 prices to calculate health-care costs over the past 5 years.

2.3.4. Control Variables—The analysis controlled for subjects' age, gender, race, and parental education (e.g., less than a high school degree, high school degree, some college, or college graduate). Parent education was included as a proxy for family socioeconomic status (SES) to control for the known health-SES gradient in children, which shows that increasing SES continually leads to better health [51].

The model controlled for school-level fixed effects by including school dummy variables. The fixed effects model accounts for unobserved factors across schools and allows for identifying the within-school connections between social networks, health and health-care costs.

Research suggests a positive association between neighborhood income and health [51]. To adjust for potential confounding by neighborhood income, the analysis included the percentage of families in the participant's census block who were at or below the poverty level, the percentage of individuals over age 25 years who had completed a college degree, and the median family income in the census block.

2.4. Statistical Analysis

2.4.1. Net monetary benefit approach—In addition to estimating QALYs and health-care cost separately, the study used a net monetary benefit (NMB) approach to evaluate the significance of adolescent peer status for both QALYs and health-care costs over a five-year span. NMB methodology is a well-established framework for the analysis of uncertainty in cost-effectiveness analysis in health economics [41]. It allows simultaneously comparing health and cost implications of multiple competing health interventions by converting health into monetary units. The NMB value is calculated as:

$$\lambda^* \mu_{\text{QALY}_i} - \mu_{\text{COST}_i},$$

where μ_{QALY_i} and μ_{COST_i} are mean QALYs and mean health-care costs in treatment group i , and λ , the cost-effectiveness threshold, is assumed to be an exogenous variable corresponding to the maximum amount that society would be willing to pay for an incremental QALY gain [52]. Intuitively, the NMB is a weighted average, which depends on λ , of health-care costs and QALYs. If λ is low, the NMB expression leans more heavily toward health-care costs. As λ increases, more weight is given to the QALY portion of the expression.

The analysis contrasted NMB by social network strata based on *in-degree* quintiles derived from the Add Health friendship survey.

2.4.2. Estimation modeling—The modeling employed a combination of probabilistic sensitivity analysis and non-parametric bootstrap analysis to estimate QALYs and health-care costs and to account for uncertainty in parameters within the various peer status strata.

2.4.3. Wave III QALY sampling distribution—To create sampling distributions for Wave III QALYs, the analysis subtracted QALYs lost for each Wave III medical condition based on average disutility reported in the literature from the full health QALY value over a five-year span [47, 48]. A generalized linear model with an identity link function (GLM) controlled for school fixed effects, individual and family characteristics (e.g., age, gender, race, parental education), and US census block neighborhood effects (e.g., poverty, college education, median income) in the resulting QALYs. The residuals from the GLM were added to the distributional mean to produce adjusted mean-centered QALYs over a five-year span for each subject. QALY values are not discounted.

2.4.4. Wave III health-care cost sampling distribution—Subjects self-reported past five-year health-care utilization in Add Health Wave III. The five-year health-care utilization counts were multiplied by US\$ costs drawn from the 2004 MEPS [50] and adjusted to the 2012 medical consumer price index. The 2004 MEPS average unit costs, adjusted to 2012 US\$, were US\$984 per emergency department visit, US\$1514 per hospitalization, US\$1215 per inpatient mental health treatment, and US\$1385 per AODA treatment episode. A GLM adjusted health-care costs for school fixed effects, individual and family characteristics, and US census block neighborhood effects, as noted above, to

produce adjusted mean-centered costs for each subject. Costs were derived from the health-care payer perspective. All costs are reported in 2012 US\$ and are not discounted.

2.4.5. Net monetary benefit (NMB) sampling distributions based on peer status—QALY and cost distributions exhibit asymmetric long-tail properties that call into question normality assumptions. As an alternative to traditional variance estimation, nonparametric bootstrapping produces confidence intervals based on the empirical distribution of cost and QALY outcomes [53, 54]. The estimation used Monte Carlo simulations to generate bivariate sampling distributions for QALYs (μ_{QALY_i}) and health-care costs (μ_{COST_i}) based on peer status in school. From the n_i observations in a given stratum, a random sample of size n_i was drawn with replacement. The simulated combinations of QALYs and health-care costs were plotted in the cost-effectiveness plane. The NMB_b was calculated for the derived bootstrap sample using the NMB value equation (1) and assuming a fixed US\$ value for λ . This process was repeated a large number of times ($N=1000$) to produce estimates of the 95% confidence interval bounds for NMB as the $N^*(0.025)$ highest and the $N^*(0.025)$ lowest values of NMB_b .

2.4.6. Net monetary benefit (NMB) conditional on cost-effectiveness threshold (λ)—The analysis computed NMB for each simulated Monte Carlo draw assuming a fixed cost-effectiveness threshold λ . Varying the US\$ value threshold λ along a sliding scale (from US\$0-US\$500 000 per QALY) allowed for alternative conversion of QALYs into monetary values. The analysis presents the US\$ value NMB differential per adolescent between quintiles at the $\lambda=\text{US\$}50\ 000/\text{QALY}$ level.

Finally, the probability of a quintile maximizing NMB relative to the other quintiles' NMB was plotted on the cost-effectiveness threshold (λ) scale.

3. Results

Table 1 shows summary statistics of demographic and household variables for the study sample. Half of the participants were males. Mean age was 15.7 years. Most (57%) respondents were non-Hispanic White, 21% were Black, 7% Asian, and 14% White Hispanic.

Table 2 provides the means and standard deviations for the QALY and health-care cost data over a five-year span by adolescent peer status (i.e. *in-degree*) quintile, after adjusting for school fixed effects, individual and family characteristics, and US census block neighborhood effects (see Online Resource 1). Adolescents with 0-1 friends experienced 4.33 QALYs (SD 0.48) over a five-year span. QALYs increased steadily up to 4.38 QALYs (SD 0.45) for adolescents with eight or more friends. On the other hand, health-care costs decreased as adolescent peer status in school increased. While mean health-care costs for socially marginalized adolescents (0-1 friends) averaged US\$6831 (SD US\$11 570), participants with 8 or more friends demonstrated US\$5165 (SD US\$9349) in health-care costs over a five-year span at Wave III. Large standard deviations for health-care costs noted in Table 2 reflect the skewed nature of the health-care cost data.

Figure 1 offers a visual interpretation of the link between adolescent peer status in school, QALYs and health-care costs over a five-year span. Each data point in Figure 1 represents a Monte Carlo simulation run of QALYs and health-care costs. As predicted, QALYs rose and health-care costs fell, respectively, as an adolescent's peer status in school increased. The top two quintiles (subjects with 6-7 and 8+ friends) had both the lowest health-care costs and greatest QALYs as opposed to the two lowest quintiles (participants with 0-1 or 2-3 friends). High peer status adolescents (6-7 or 8+ friends) enjoyed QALYs in the 4.36 to 4.40 range,

while lower peer status adolescents (0-1 or 2-3 friends) experienced 4.31 to 4.35 QALYs respectively. Adolescents in the highest *in-degree* quintile (8+ friends) averaged US\$4500 to US\$5500 in five-year health-care costs compared to US\$6300 to US\$7300 five-year health-care costs for socially disengaged adolescents in the lowest *in-degree* quintile (0-1 friends).

NMB is a measure of the five-year cumulative health (QALYs) of the individual converted into US\$ minus the individual's five-year health-care costs. Table 3 presents NMB values at the US\$25 000 and US\$50 000 levels for the cost-effectiveness threshold λ . With QALYs valued at US\$25 000, the highest peer status adolescents (8+ friends) averaged NMB of US\$104 400 across all Monte Carlo simulations. NMB for adolescents with 0-1 friends were significantly lower (US\$101 400, $p < .001$). Similarly, at US\$50 000 per QALY, the highest peer status adolescents experienced significantly greater NMB (US\$214 000) than low peer status adolescents (US\$209 700, $p < .001$, and US\$209 900, $p < .001$, for 0-1 friends and 2-3 friends, respectively). The NMB results translate into 4.29 QALYs (95% CI 4.26, 4.32) over 5 years for an adolescent with 8+ friends compared to 4.19 QALYs (95% CI 4.16, 4.23) for an adolescent with 0-1 friends. When valuing NMB at $\lambda = \text{US\$50 000/QALY}$, the NMB differential between the lowest *in-degree* quintile and the higher *in-degree* quintiles ranged from US\$138 to US\$4440 in additional health-care costs and/or reduced quality-adjusted life years per adolescent over a five-year span (see Table 3). The increase in NMB between the 0-1 friend quintile and the 4-5 friend quintile was US\$2546. The average NMB increase associated with a single stratum step-up in peer status was US\$1110.

Figure 2 demonstrates the proportion of Monte Carlo simulation runs ($N=1000$) in which each *in-degree* stratum produced the maximum NMB compared to the other strata, as a function of the cost-effectiveness threshold λ . As seen in Figure 2, in 100% of the Monte Carlo simulation runs, the maximum NMB occurred in either the 4th (6-7 friends) or 5th (8+ friends) *in-degree* quintile.

3.1. Robustness

The analyses estimated QALYs and health-care costs using alternative peer status in school measures as presented in Table 4. School peer status was alternatively defined as the adolescent's *out-degree* (friendship nominations to other adolescents), *send-receive network* (adolescents sending a friendship nomination to and/or receiving a friendship nomination from the adolescent), *Bonacich centrality* (friendship connections to adolescents who themselves have many friendship connections), *3-step reach* (adolescents reachable within 3 steps of friendship connection), and *local density* (percent of friendship connections within an adolescent's send-receive network from total friendship connections possible). Increases in peer status were generally associated with increases in NMB. Full results are available upon request.

4. Discussion

The study findings suggest that after adjusting for school fixed effects and socioeconomic status [51, 55], higher adolescent peer status in school is positively associated with significantly better net monetary benefit. At the US\$50 000 per QALY level, adolescents who had 8 or more friends accumulated US\$214 300 in net monetary benefit over five years. In comparison, socially marginalized adolescents, those with 0-1 friends, attained US\$209 900 in net monetary benefit over a five-year span. This peer status difference translates into roughly US\$4440 in increased health costs and/or reduced QALYs per socially disengaged adolescent over 5 years. The findings are robust to alternative definitions of peer status in school and to alternative US\$ thresholds for converting costs to QALYs.

In view of the fundamental human need for interpersonal attachment and belonging [56], the presence of socially marginalized children in schools could be indicative of a school environment that does not promote student health [8]. Subtle changes in adolescent social functioning in a school's peer social networks at the time when they just begin to build their self-identity may set in motion important changes in children's mental and physical well-being which may persist into adulthood. Consequently, teachers may hold a unique opportunity to promote better later-in-life health by targeting peer group structures in schools and engaging socially disengaged students [57-60].

We caution, however, that the observational nature of the available data limits our ability to conclusively draw a definitive causal link from adolescent peer status in schools to later health in adulthood. Our study findings only reveal a consistently strong association between peer status in school and later health across different definitions of peer status. Our longitudinal analysis over 5 years post initial observation suggests a dose-response relationship such that each additional step-up in adolescent peer status in school is associated with better health outcomes. Our results could be viewed in light of an emerging body of literature which identifies plausible biological mechanisms for the association between adolescent peer status in school and health. Further evidence is needed on the causality underlying this association as well as on the comparative costs and benefits of health interventions targeting adolescent peer group structures in schools as a means to promote better health. The study findings call for randomized controlled trials to investigate these issues further.

While keeping in mind the potentially large degree of variability in health-care cost data and the lack of a definitive causal pathway between peer status in school and health, it may be informative to put the study results in perspective. If our findings hold in future experimental studies, fostering cohesive classrooms with more evenly distributed peer friendships among students that could allow isolated students (0-1 friends) to gain an average number of friendship nominations (4-5 friends) has the potential to save up to US \$2546 in future health-care costs and/or reduced quality-adjusted life years per marginalized student over a five-year span. If such interventions targeting peer group structures prove to be successful, it is conceivable that a school district with 10 000 secondary school students (e.g., a city of 250 000 residents), with 20% of students being marginalized as in our study sample (i.e., 0-1 friends), could potentially avoid up to US\$5.1 million in future health-care costs and/or reduced quality-adjusted life years over a five-year span. In view of the magnitude of the potential health-care cost savings, our results call for randomized controlled trials evaluating the costs and benefits of school-based social network interventions targeting peer group structures as a means to promote better health in adulthood.

The study has several limitations. First, to estimate QALYs and health-care costs, the analysis relied on subject recall, average disutilities, and average emergency department, hospital, mental health, and alcohol or drug treatment costs. Although these data sources were the best available at the time of the analysis, the cost and QALY data may be subject to both recall and measurement error. Direct health-care reimbursements and a QALY instrument that could be directly assigned a utility weight would have been preferable [61]. Second, the estimates of health-care costs did not include primary care visits or medication costs. From this perspective, the analysis may underestimate the total health-care costs related to adolescent peer status in school. Third, we did not distinguish health-care costs due to pregnancy and childbirth. Pregnancy health-care costs were not available in the data. However, US average charges for pregnancy care with vaginal and cesarean delivery were US\$32 093 and US\$51 125, respectively, in 2010 [62], which suggests that our findings may undervalue the total health-care costs associated with peer status in school. Fourth, the

sample of adolescents enrolled in the study may not be representative of adolescents nationally and may not characterize acute events (e.g., loss of friends due to re-location). The study excluded subjects who were not present in school or not included on the school roster at the time of initial survey (i.e., no home schooling), which influences the generalizability of the conclusions. Fifth, the analysis, by limiting itself to friendships within a school, may not have captured all social interactions which were meaningful for the adolescents in the study. However, school-based social networks may be most applicable to health promoting interventions targeting peer group structures. Finally, the valuation does not provide standard errors around the cost estimates because of the secondary nature of the health-care visit cost data. Readers are cautioned about the potentially large degree of variability in costs for health-care visits.

4.1. Conclusion

Adolescent peer status in schools may be contributing to the root causes of adult health outcomes. Adolescents with high peer status in schools have significantly better health and lower health-care costs in young adulthood. Randomized controlled trials targeting peer group structures as a means of promoting better health in adulthood are called for.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors would like to thank Benjamin Craig, Mindy Smith, and John Mullahy for their valuable comments and suggestions. This research uses data from Add Health, a program project directed by Kathleen Mullan Harris and designed by J. Richard Udry, Peter S. Bearman, and Kathleen Mullan Harris at the University of North Carolina at Chapel Hill, and funded by grant P01-HD31921 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development, with cooperative funding from 23 other federal agencies and foundations. Special acknowledgment is due Ronald R. Rindfuss and Barbara Entwisle for assistance in the original design. Information on how to obtain the Add Health data files is available on the Add Health website (<http://www.cpc.unc.edu/addhealth>). No direct support was received from grant P01-HD31921 for this analysis.

References

1. De Silva MJ, McKenzie K, Harpham T, Huttly SR. Social capital and mental illness: A systematic review. *J Epidemiol Community Health.* Aug; 2005 59(8):619–27. [PubMed: 16020636]
2. Wolff FC. Well-being of elderly people living in nursing homes: The benefits of making friends. *Kyklos.* Feb; 2013 66(1):153–71.
3. Holt-Lunstad J, Smith TB, Layton JB. Social relationships and mortality risk: A meta-analytic review. *PLoS Med.* Jul.2010 7(7):e1000316. [PubMed: 20668659]
4. Kawachi I, Berkman LF. Social ties and mental health. *J Urban Health.* Sep; 2001 78(3):458–67. [PubMed: 11564849]
5. Almqvist Y. Peer status in school and adult disease risk: A 30-year follow-up study of disease-specific morbidity in a Stockholm cohort. *J Epidemiol Community Health.* Dec; 2009 63(12):1028–34. [PubMed: 19789170]
6. Caspi A, Harrington H, Moffitt TE, Milne BJ, Poulton R. Socially isolated children 20 years later: Risk of cardiovascular disease. *Arch Pediatr Adolesc Med.* Aug; 2006 160(8):805–11. [PubMed: 16894079]
7. Ostberg V, Modin B. Status relations in school and their relevance for health in a life course perspective: Findings from the Aberdeen children of the 1950's cohort study. *Soc Sci Med.* Feb; 2008 66(4):835–48. [PubMed: 18158207]
8. Östberg V. Children in classrooms: Peer status, status distribution and mental well-being. *Soc Sci Med.* 2003; 56(1):17–29. [PubMed: 12435548]

9. Viner RM, Ozer EM, Denny S, Marmot M, Resnick M, Fatusi A, et al. Adolescence and the social determinants of health. *Lancet*. Apr 28; 2012 379(9826):1641–52. [PubMed: 22538179]
10. Moody J, Brynildsen WD, Osgood DW, Feinberg ME, Gest S. Popularity trajectories and substance use in early adolescence. *Soc Networks*. May; 2011 33(2):101–12. [PubMed: 21765588]
11. Kiesner J. Depressive symptoms in early adolescence: Their relations with classroom problem behavior and peer status. *J Res Adolescence*. 2002; 12(4):463–78.
12. Almquist Y. Social isolation in the classroom and adult health: A longitudinal study of a 1953 cohort. *Adv Life Course Res*. 2011; 16(1):1–12.
13. Cillessen AHN, Rose AJ. Understanding popularity in the peer system. *Curr Dir Psychol Sci*. Apr; 2005 14(2):102–5.
14. Morgan A, Haglund BJ. Social capital does matter for adolescent health: Evidence from the English HBSC study. *Health Promot Int*. Dec; 2009 24(4):363–72. [PubMed: 19717401]
15. Torsheim T, Wold B. School-related stress, school support, and somatic complaints: A general population study. *J Adolescent Res*. 2001; 16(3):293–303.
16. Aslund C, Starrin B, Nilsson KW. Social capital in relation to depression, musculoskeletal pain, and psychosomatic symptoms: A cross-sectional study of a large population-based cohort of Swedish adolescents. *BMC Public Health*. 2010; 10:715. [PubMed: 21092130]
17. Borges CM, Campos AC, Vargas AD, Ferreira EF, Kawachi I. Social capital and self-rated health among adolescents in Brazil: An exploratory study. *BMC Res Notes*. 2010; 3:338. [PubMed: 21162730]
18. Berra S, Tebe C, Erhart M, Ravens-Sieberger U, Auquier P, Detmar S, et al. Correlates of use of health care services by children and adolescents from 11 European countries. *Med Care*. Feb; 2009 47(2):161–7. [PubMed: 19169116]
19. Bernal P, Estroff DB, Aboudarham JF, Murphy M, Keller A, Jellinek MS. Psychosocial morbidity: The economic burden in a pediatric health maintenance organization sample. *Arch Pediatr Adolesc Med*. Mar; 2000 154(3):261–6. [PubMed: 10710024]
20. Neill SJ. Containing acute childhood illness within family life: A substantive grounded theory. *J Child Health Care*. Dec; 2010 14(4):327–44. [PubMed: 20823078]
21. Nolan SA, Flynn C, Garber J. Prospective relations between rejection and depression in young adolescents. *J Pers Soc Psychol*. Oct; 2003 85(4):745–55. [PubMed: 14561127]
22. Layous K, Nelson SK, Oberle E, Schonert-Reichl KA, Lyubomirsky S. Kindness counts: Prompting prosocial behavior in preadolescents boosts peer acceptance and well-being. *PLoS One*. 2012; 7(12):e51380. [PubMed: 23300546]
23. Cohen S. Social relationships and health. *Am Psychol*. Nov; 2004 59(8):676–84. [PubMed: 15554821]
24. Uchino BN. Social support and health: A review of physiological processes potentially underlying links to disease outcomes. *J Behav Med*. Aug; 2006 29(4):377–87. [PubMed: 16758315]
25. Umberson D, Montez JK. Social relationships and health: a flashpoint for health policy. *J Health Soc Behav*. 2010; 51(Suppl):S54–66. [PubMed: 20943583]
26. Adams RE, Santo JB, Bukowski WM. The presence of a best friend buffers the effects of negative experiences. *Dev Psychol*. Nov; 2011 47(6):1786–91. [PubMed: 21895364]
27. Garber J. Depression in children and adolescents - Linking risk research and prevention. *Am J Prev Med*. Dec; 2006 31(6):S104–S25. [PubMed: 17175406]
28. Witvliet M, Brendgen M, van Lier PAC, Koot HM, Vitaro F. Early Adolescent Depressive Symptoms: Prediction from Clique Isolation, Loneliness, and Perceived Social Acceptance. *J Abnorm Child Psychol*. Nov; 2010 38(8):1045–56. [PubMed: 20499155]
29. Bandura, A. Social foundations of thought and action: A social cognitive theory. Prentice-Hall; Englewood Cliffs, NJ: 1986.
30. Schulenberg J, Wadsworth KN, OMalley PM, Bachman JG, Johnston LD. Adolescent risk factors for binge drinking during the transition to young adulthood: Variable- and pattern-centered approaches to change. *Dev Psychol*. Jul; 1996 32(4):659–74.
31. Rimal RN. Closing the knowledge-behavior gap in health promotion: The mediating role of self-efficacy. *Health Commun*. 2000; 12(3):219–37. [PubMed: 10938914]

32. Haegerich, TM.; Tolan, PH. Core Competencies and the Prevention of Adolescent Substance Use. In: Guerra, NG.; Bradshaw, CP., editors. Core Competencies to Prevent Problem Behaviors and Promote Positive Youth Development. Jossey-Bass; San Francisco: 2008. p. 47-60.
33. Karatzias A, Power KG, Swanson V. Predicting use and maintenance of use of substances in Scottish adolescents. *J Youth Adolescence*. Aug; 2001 30(4):465–84.
34. Marmot MG, Shipley MJ, Rose G. Inequalities in death: Specific explanations of a general pattern? *Lancet*. 1984; 1(8384):1003–6. [PubMed: 6143919]
35. Eisenberger NI, Taylor SE, Gable SL, Hilmert CJ, Lieberman MD. Neural pathways link social support to attenuated neuroendocrine stress responses. *Neuroimage*. May 1; 2007 35(4):1601–12. [PubMed: 17395493]
36. Hennessy MB, Kaiser S, Sachser N. Social buffering of the stress response: Diversity, mechanisms, and functions. *Front Neuroendocrinol*. Oct; 2009 30(4):470–82. [PubMed: 19545584]
37. Seeman TE, McEwen BS. Impact of social environment characteristics on neuroendocrine regulation. *Psychosom Med*. 1996; 58(5):459–71. [PubMed: 8902897]
38. Kyrou I, Tsigos C. Stress hormones: physiological stress and regulation of metabolism. *Curr Opin Pharmacol*. Dec; 2009 9(6):787–93. [PubMed: 19758844]
39. McEwen BS, Seeman T. Protective and damaging effects of mediators of stress - Elaborating and testing the concepts of allostasis and allostatic load. *Ann Ny Acad Sci*. 1999; 896:30–47. [PubMed: 10681886]
40. Needham BL, Fernandez JR, Lin J, Epel ES, Blackburn EH. Socioeconomic status and cell aging in children. *Soc Sci Med*. Jun; 2012 74(12):1948–51. [PubMed: 22472277]
41. Stinnett AA, Mullahy J. Net health benefits: A new framework for the analysis of uncertainty in cost-effectiveness analysis. *Med Decis Making*. Apr-Jun; 1998 18(2):S68–S80. [PubMed: 9566468]
42. Harris, KM.; Halpern, CT.; Whitsel, E.; Hussey, J.; Tabor, J.; Entzel, P., et al. National longitudinal study of adolescent health: Research design. 2012. [cited 2012 December 12]; Available from: <http://www.cpc.unc.edu/projects/addhealth/design>
43. Drummond, MF.; Sculpher, MJ.; Torrance, GW. Methods for the economic evaluation of health care programmes. 3rd ed.. Oxford University Press; Oxford: 2005.
44. Gold, MR.; Siegel, JE.; Russell, LB.; Weinstein, MC. Cost effectiveness in health and medicine. Oxford University Press; New York: 1996.
45. Hjelmgren J, Berggren F, Andersson F. Health economic guidelines: Similarities, differences and some implications. *Value Health*. May-Jun; 2001 4(3):225–50. [PubMed: 11705185]
46. Haley SM, Mchorney CA, Ware JE. Evaluation of the MOS SF-36 Physical Functioning Scale (PF-10) .1. Unidimensionality and Reproducibility of the Rasch Item Scale. *J Clin Epidemiol*. Jun; 1994 47(6):671–84. [PubMed: 7722580]
47. Sullivan PW, Ghushchyan V. Preference-based EQ-5D index scores for chronic conditions in the United States. *Med Decis Making*. Jul-Aug; 2006 26(4):410–20. [PubMed: 16855129]
48. Sullivan PW, Lawrence WF, Ghushchyan V. A national catalog of preference-based scores for chronic conditions in the United States. *Med Care*. Jul; 2005 43(7):736–49. [PubMed: 15970790]
49. Shaw JW, Johnson JA, Coons SJ. US valuation of the EQ-5D health states - Development and testing of the D1 valuation model. *Med Care*. Mar; 2005 43(3):203–20. [PubMed: 15725977]
50. Agency for Healthcare Research and Quality. MEPS HC-085E: 2004 Emergency Room Visits. 2006. Medical Expenditure Panel Survey. [cited 2012 December 12]; Available from: http://meps.ahrq.gov/mepsweb/data_stats/download_data/pufs/h85e/h85edoc.shtml
51. Fletcher, J.; Wolfe, BL. Increasing our understanding of the health-income gradient in children. Cambridge, Mass., USA: 2012.
52. Jena AB, Philipson TJ. Cost-effectiveness analysis and innovation. *J Health Econ*. Sep; 2008 27(5):1224–36. [PubMed: 18619695]
53. Davidson, R.; MacKinnon, JG. Estimation and inference in econometrics. Oxford University Press; New York: 1993.
54. Efron, B.; Tibshirani, RJ. An introduction to the bootstrap. Chapman and Hall; London: 1993.

55. Conti, G.; Heckman, J. IZA Discussion Paper. 2012;No. 7060. Dec. 2012 The developmental approach to child and adult health.
56. Baumeister RF, Leary MR. The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychol Bull.* May; 1995 117(3):497–529. [PubMed: 7777651]
57. Farmer TW, Xie H. Aggression and school social dynamics: The good, the bad, and the ordinary. *J Sch Psychol.* Oct; 2007 45(5):461–78.
58. Farmer TW, Lines MM, Hamm JV. Revealing the invisible hand: The role of teachers in children's peer experiences. *J Appl Dev Psychol.* Sep-Oct;2011 32(5):247–56.
59. Cunha F, Heckman J, Schennach S. Estimating the technology of cognitive and noncognitive skill formation. *Econometrica.* May 1; 2010 78(3):883–931. [PubMed: 20563300]
60. Roseth CJ, Johnson DW, Johnson RT. Promoting early adolescents' achievement and peer relationships: The effects of cooperative, competitive, and individualistic goal structures. *Psychol Bull.* 2008; 134(2):223–46. [PubMed: 18298270]
61. Ratcliffe J, Couzner L, Flynn T, Sawyer M, Stevens K, Brazier J, et al. Valuing Child Health Utility 9D health states with a young adolescent sample: a feasibility study to compare best-worst scaling discrete-choice experiment, standard gamble and time trade-off methods. *Appl Health Econ Health Policy.* 2011; 9(1):15–27. [PubMed: 21033766]
62. Truven Health Analytics. The Cost of Having a Baby in the United States. 2013. [cited 2013 July 25]; Available from: <http://transform.childbirthconnection.org/wp-content/uploads/2013/01/Cost-of-Having-a-Baby1.pdf>

Key points for decision makers

- Adolescents with higher peer status in school have better health and lower health-care costs as young adults
- Up to US\$4440 per socially disengaged adolescent over 5 years in US health and health-care costs may be related to adolescent marginalization in their peer group
- Randomized controlled trials are needed to assess the costs and benefits of interventions targeting adolescent peer group structure in school as a means to promote better health in adulthood

Fig. 1. Health Costs and Quality-Adjusted Life Years (QALYs) by Adolescent Peer Status (*In-Degree Quintiles*)

Fig. 2. Maximization of Net Monetary Benefit by Peer Status (*In-Degree*) (n=10 578)
 QALY: Quality-Adjusted Life Year

Table 1
Descriptive Statistics of the Wave I Add Health¹ Sample (n=10 578)

<i>Demographics</i>	<i>Mean</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>
Male	0.501	0.500	0	1
Age	15.655	1.717	12	18
Grade Level				
7th grade	0.130	0.337	0	1
8th grade	0.132	0.338	0	1
9th grade	0.178	0.382	0	1
10th grade	0.194	0.395	0	1
11th grade	0.193	0.395	0	1
12th grade	0.173	0.379	0	1
Race				
Non-Hispanic White	0.567	0.496	0	1
Black	0.208	0.406	0	1
Native American	0.013	0.115	0	1
Asian	0.067	0.250	0	1
White Hispanic	0.144	0.352	0	1
<i>Household Characteristics</i>				
Parental Education				
Mom <HS graduate	0.166	0.385	0	1
Mom HS graduate	0.415	0.493	0	1
Mom some college	0.137	0.344	0	1
Mom college degree	0.282	0.456	0	1
Dad <HS graduate	0.219	0.428	0	1
Dad HS graduate	0.384	0.486	0	1
Dad some college	0.114	0.317	0	1
Dad college degree	0.283	0.451	0	1
<i>Neighborhood Characteristics</i>				
Median family income (US\$)	35 089	8741	14 721	61 132
Proportion of families < poverty level	0.121	0.130	0	0.859
Proportion aged 25+ with college degree	0.225	0.144	0	0.944
<i>Social Interaction</i>				
Nominations received (in-degree)	4.577	3.100	0	32
Nominations sent (out-degree)	4.427	3.016	0	10
Send-receive network	8.155	4.309	0	33
Bonacich centrality	0.826	0.645	0	4.288
3-step reach	57.083	47.414	0	267
Local density	0.407	0.202	0.091	1

¹ Add Health: The National Longitudinal Study of Adolescent Health

Table 2
Mean Health-Care Costs and Quality-Adjusted Life Years (QALYs) by Adolescent Peer Status (*In-Degree*) (N=10 578)

<i>In-degree</i>	<i>n</i>	<i>Health-care costs mean (SD)</i>	<i>QALYs mean (SD)</i>
0-1 friends	2,176	US\$6831 (US\$11 570)	4.33 (0.48)
2-3 friends	2,861	US\$7027 (US\$17 279)	4.34 (0.48)
4-5 friends	2,199	US\$6603* (US\$15 603)	4.37*** (0.46)
6-7 friends	1,476	US\$5987*** (US\$12 551)	4.38*** (0.47)
8-32 friends	1,830	US\$5165*** (US\$9349)	4.38*** (0.45)

* p<.05 compared to 1st quintile using Kruskal-Wallis nonparametric test

** p<.01 compared to 1st quintile using Kruskal-Wallis nonparametric test

*** p<.001 compared to 1st quintile using Kruskal-Wallis nonparametric test

Table 3
Net Monetary Benefit (NMB) by Peer Status (*In-Degree*) (n=10 578)

<i>In-degree</i>	<i>n</i>	NMB (US\$,000s) at $\lambda=US\$25\ 000/QALY$	NMB (US\$,000s) at $\lambda=US\$50\ 000/QALY$	NMB differential at $\lambda=US\$50\ 000/QALY$
0-1 friends	2176	101.4 (100.6, 102.2)	209.9 (207.9, 211.7)	...
2-3 friends	1861	101.4 (100.4, 102.2)	210.1 (208.1, 210.6)	US\$138 (-US\$2183, US\$2705)
4-5 friends	2199	102.8* (101.8, 103.6)	212.5** (211.2, 213.7)	US\$2546 (US\$309, US\$4893)
6-7 friends	1476	103.4** (102.3, 104.3)	213.1*** (212.1, 214.1)	US\$3745 (US\$2098, US\$5391)
8-32 friends	1830	104.4*** (103.6, 105.1)	214.3*** (212.8, 215.8)	US\$4440 (US\$2036, US\$6825)

Table values display NMB per peer social status quintile and NMB differentials between 0-1 friends quintile and subsequent in-degree quintiles at US\$50 000/QALY, with 95% Confidence Intervals in ();

λ : Cost-effectiveness threshold;

QALY: Quality-Adjusting Life Year

* p<.05 compared to 1st quintile

** p<.01 compared to 1st quintile

*** p<.001 compared to 1st quintile

Table 4
Net Monetary Benefit for Peer Status Measured with Alternative Social Network Parameters (n=10 578)

	<i>n</i>	<i>US\$25 000/QALY</i>	<i>λ (US\$/QALY)</i> <i>US\$50 000/QALY</i>	<i>US\$100 000/QALY</i>
<u>Out-degree</u>				
0-1 friends	2319	101.7 (100.7, 102.6)	210.1 (208.6, 211.5)	426.9 (424.4, 429.4)
2-3 friends	1882	101.8 (100.7, 103.0)	210.8 (209.3, 212.3)	428.7* (426.1, 431.3)
4-5 friends	2300	102.0* (100.9, 102.9)	210.5* (209.1, 211.9)	427.4 (425.1, 430.0)
6-7 friends	2004	103.2*** (102.4, 103.9)	212.4** (211.3, 213.6)	431.0** (428.9, 433.0)
8-10 friends	2037	103.1* (102.4, 103.8)	212.3* (211.2, 213.3)	430.6* (428.8, 432.3)
<u>Send-receive network</u>				
0-3 friends	2309	101.3 (100.4, 102.1)	209.6 (208.3, 210.8)	426.2 (424.0, 428.3)
4-5 friends	1832	101.9 (100.6, 103.0)	210.6 (209.0, 212.2)	428.1 (425.6, 430.7)
6-7 friends	1813	102.4 (101.4, 103.3)	211.4* (209.9, 212.7)	429.3** (426.7, 431.5)
8-10 friends	2390	103.1*** (102.4, 103.8)	212.5*** (211.3, 213.5)	431.1*** (429.0, 433.0)
11-33 friends	2198	103.5*** (102.8, 104.3)	212.7*** (211.6, 213.8)	431.0*** (429.1, 433.0)
<u>Bonacich centrality</u>				
0-0.18432	2108	101.7 (100.7, 102.6)	210.1 (208.6, 211.5)	426.9 (424.4, 429.4)
0.18432-0.5589	2109	101.7 (100.7, 102.5)	210.4 (209.0, 211.7)	427.8 (425.5, 430.0)
0.5589-0.9224	2108	102.0 (100.9, 102.9)	210.7 (209.2, 212.1)	428.1 (425.8, 430.4)
0.9224-1.3728	2109	103.1** (102.2, 103.8)	212.3** (211.1, 213.5)	430.9** (428.7, 432.8)
1.3728-4.5	2108	103.6*** (102.9, 104.3)	212.9*** (211.8, 213.9)	431.4** (429.4, 433.3)
<u>3-step reach</u>				
0-9 friends	2137	101.7 (100.7, 102.5)	210.1 (208.7, 211.5)	426.9 (424.4, 429.4)
10-37 friends	2088	102.3* (101.5, 103.1)	211.3** (210.1, 212.5)	429.3** (427.2, 431.4)
38-63 friends	2102	102.6* (101.9, 103.4)	211.7* (210.5, 212.9)	429.8* (427.7, 431.9)
64-97 friends	2107	102.8* (101.8, 103.7)	211.8* (210.4, 213.1)	429.9** (427.5, 432.0)
98-267 friends	2108	102.7* (101.8, 103.5)	211.5* (210.1, 212.9)	429.2* (426.8, 431.5)
<u>Local density</u>				
0-0.1806	2012	102.2 (101.4, 103.1)	210.7 (209.4, 212.0)	427.7 (425.4, 430.0)
0.1806-0.234	2013	103.1 (102.3, 103.8)	212.4* (211.1, 213.5)	430.8* (428.8, 432.9)
0.234-0.299	1929	102.4 (101.4, 103.3)	211.4 (210.0, 212.7)	429.4 (427.0, 431.7)
0.299-0.382	2120	102.3 (101.1, 103.3)	211.2 (209.6, 212.6)	428.9 (426.3, 431.4)
0.382-1.000	2115	102.5 (101.6, 103.3)	211.2 (210.0, 212.5)	428.8 (426.7, 431.0)

Table values display Net Monetary Benefit per peer social status quintile, with 95% Confidence Intervals in ();

λ : Cost-effectiveness threshold;

QALY: Quality-Adjusted Life Year;

Out-degree: number of friendship nominations sent to other students at Wave I;

Send-receive network: total number of students an adolescent sent a friendship nomination to or received a friendship nomination from;

Bonacich centrality: degree to which an adolescent had friendship connections to adolescents who themselves had many friendship connections;

3-step reach: number of other students an adolescent could reach within 3 steps of friendship connection;

Local density: interconnectedness between friends, measured by the percent of friendship connections present within an individual's send-receive network out of the total number of friendship connections possible.

*
p<.05 compared to 1st quintile

**
p<.01 compared to 1st quintile

p<.001 compared to 1st quintile