Socioeconomic position and intergenerational associations of ideal health behaviors

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ABSTRACT

Background. Promoting ideal cardiovascular health behaviors is an objective of the American Heart Association (AHA) 2020 goals. We hypothesized that ideal health behaviors of parents are associated with health behaviors of their adult offspring, and that higher socioeconomic position (SEP) in either generation enhances intergenerational associations of ideal health behaviors.

Design: Prospective cohort study.

Methods: We included 1856 Young Finns Study participants who had repeated measurements of SEP (education, income, occupation), smoking status, BMI, physical activity and diet from 2001, 2007 and 2011, and data on parental SEP and health behaviors from 1980. We calculated the total number of ideal behaviors in both generations using AHA definitions. Intergenerational associations were examined using ordinal and linear multilevel regression with random intercepts, where each participant contributed one, two or three measurements of adult health behaviors (2001, 2007, 2011). All analyses were adjusted for offspring sex, birth year, age, parental education and single-parenthood.

Results. Overall, parental ideal health behaviors were associated with ideal behaviors among offspring (OR=1.28, 95% CI, 1.17,1.39). Furthermore, ORs for these intergenerational associations were greater among offspring whose parents or who themselves had higher educational attainment (OR=1.56 for high vs OR=1.19 for low parental education; p=0.01 for interaction, OR=1.32 for high vs OR=1.04 for low offspring education; p=0.02 for interaction). Similar trends were seen with parental income and offspring occupation. Results from linear regression analyses were similar.

Conclusions. These prospective data suggest higher SEP in parents or in their adult offspring strengthens the intergenerational continuum of ideal cardiovascular health behaviors.

Abstract word count: 250

Keywords: cohort studies, family, health behavior, social class

INTRODUCTION

Health behaviors are recognized as major determinants of cardiovascular health and longevity.[1–4] In their 2020 Strategic Impact Goal of improving the cardiovascular health of the population by 20%, the American Heart Association (AHA) defined ideal levels of four health behaviors to help monitor progress – non-smoking, body-mass index (BMI), physical activity and diet.[1] Ideal levels of these behaviors are associated with lower incidence of cardiovascular disease, better cardiometabolic health, and disease-free survival.[1–3]

Health behaviors of offspring tend to correlate with health behaviors of their parents. Such intergenerational associations have been documented for all health behaviors included in the AHA definition,[5–10] and several studies have demonstrated that behavioral patterns adopted in childhood and adolescence track into adulthood.[11–14] Most previous research examining intergenerational associations has focused on single behavioral risk factors such as smoking or BMI. However, health behaviors are intercorrelated, and simultaneous adherence to several optimal health behaviors is known to reduce cardiovascular risk.[2,3]

To promote optimal health behaviors across generations, it is crucial to identify factors that might enhance or attenuate the intergenerational associations of health behaviors. Socioeconomic differences – both in childhood and adulthood – have been consistently associated with differences in health behaviors, with optimal behavioral patterns more often found among people with higher socioeconomic position (SEP).[15–19] Higher SEP has been associated with higher reserve capacity – a generic protective influence on health through resources available to an individual that help maintain optimal functioning and healthy status.[20,21] Thus higher SEP might be expected to promote the associations of healthy behaviors across generations. Some studies suggest that SEP in childhood may affect how health behaviors are passed on from one generation to the next, but the evidence is not consistent.[7,22,23] Moreover, data are sparse on the role of SEP in both childhood and adulthood in modifying the intergenerational associations, although this knowledge is potentially relevant to long-term health promotion.

We used prospective intergenerational data with repeated measurements of health behaviors and SEP over 31 years to examine the intergenerational associations of a set of ideal health behaviors defined by AHA. We hypothesized that ideal behaviors of parents are associated with ideal behaviors of their offspring, and that higher SEP in parents and their offspring promotes the intergenerational associations of ideal health behaviors.

METHODS

Sample

The Cardiovascular Risk in Young Finns Study is a prospective cohort study following individuals from childhood to adulthood on the determinants of cardiovascular disease (between 1980 and 2011). In this study, we used data from 1980, 2001, 2007 and 2011 (see Supplemental Material Table 1). The original sample comprised 3596 individuals (aged 3-18 at study inception in 1980).[24] A total of 2345 participants met the inclusion criterion for this study as they had data on parental health behaviors and parental SEP in 1980. Of the 2345 participants initially eligible, 293 were omitted due to missing data on adult educational attainment at all follow-ups in 2001, 2007 and 2011, and an additional 196 due to missing data on adult health behaviors at all follow-ups in 2001, 2007 and 2011, leaving a study population of 1856. The study was conducted according to the Declaration of Helsinki and approved by local ethics committees. All participants gave written informed consent.

Measures

Participant's health behaviors. Four health behaviors defined by the AHA guidelines – smoking, BMI, physical activity and diet – were assessed from participants at three follow-ups in 2001, 2007 and 2011. Smoking, physical activity and diet were self-reported. BMI (kg/m^2) was measured during a study visit. Criteria for ideal smoking status, BMI and physical activity were met if the participant never smoked or quit >1 year ago; had a BMI <25 kg/m^2, engaged in 120 min/week moderate-intensity or 60 min/week vigorous-intensity activity or a combination.[25,26] In 2007 and 2011, ideal diet was defined comprising 4/5 ideal dietary components based on a food-frequency questionnaire (FFQ) on frequency and portion size (semi-quantitative FFQ) and scaled for caloric intake: ≥450 g/day of fruits and vegetables; ≥two servings (100 g) of fish/week; ≥three servings (30 g) of whole grain rye bread/day; <1500 mg of sodium/day; ≤450 kcal of sugar-sweetened beverages/week.[1] In 2001, ideal diet was defined comprising 2/3 components based on an FFQ on frequency (non-quantitative FFQ): fruits and vegetables every day; fish ≥2 times/week; and soft drinks ≤2 times/week.[25,26]

The total number of ideal health behaviors was calculated as the count of ideal scores on smoking, BMI, physical activity and diet and ranged from 0 to 4.

Parental health behaviors. Parental health behaviors defined by the AHA guidelines were assessed via parents' self-reports at study inception in 1980. Criteria for ideal smoking status, BMI and physical activity were met if the parent never smoked or quit >1 year ago; had a BMI <25 kg/m^2, and exercised regularly at least once a week. As no satisfactory measurement was available for diet in 1980, we used dietary information measured from the participants in 1986 as a proxy for family food environment. Ideal family diet was defined as diet comprising 2/3 dietary components based on an FFQ on frequency (non-quantitative FFQ): fruits and vegetables every day; fish ≥2 times/week; and soft drinks ≤2 times/week.[25,26]

The total number of ideal health behaviors was calculated as the sum of parental scores on smoking, BMI, physical activity and diet. In two-parent families, each parent contributed separately so that scales of smoking, BMI and physical activity ranged from 0 to 2 (0 – non-ideal behavior in both parents, 1 – ideal behavior in only one parent, 2 – ideal behavior in both parents).[17] Diet was assessed on a two-point scale (0 – non-ideal family diet, 2 – ideal family diet). The total number of parental ideal health behaviors ranged thus from 0 to 8.

Participant SEP. Data on SEP was collected from participant self-reports at three follow-ups in 2001, 2007 and 2011 (except income only in 2007 and 2011). *Educational attainment* (highest level of educational attendance or completed education) was used as the primary measure of SEP, categorized in four ascending groups: primary education, secondary education, Bachelor's degree program or equivalent; Master's degree program or higher. *Gross annual income* was measured on a 7-point scale ranging from 0 (0-10 000 EUR) to 6 (>60 000 EUR). *Occupational status* was classified into manual, lower non-manual and higher non-manual (0/1/2) according to the classification of Statistics Finland.

Parental SEP. Data on parental SEP was collected via parents' self-reports at study inception in 1980. *Parental educational attainment* (measured as completed years of schooling) was used as the primary measure of parental SEP, categorized into four ascending groups: ≤9 years; 10-12 years; 13-15 years; >15 years. In two-parent families, data from the more educated parent was used, and we also examined mother's and father's educational attainment separately. *Parental income* was measured as the previous year's household gross income in Finnish marks on a 7-point scale ranging from 0 (0-25 000 FIM) to 6 (>100 000 FIM) in 1980 (1 FIM in 1979 corresponds to ca 0.56 EUR in 2019). *Parental occupational status* was classified into manual, lower non-manual, higher non-manual according to the classification of Statistics Finland. In two-parent families, data from parent with higher occupational status was used.

Potential confounders. All analyses were adjusted for offspring sex, birth year, age and parental education due to established associations of childhood socioeconomic environment with parental and offspring health behaviors and offspring adulthood SEP.[27–29]

Statistical analyses

We used random-intercept multilevel ordinal logistic regression to assess the intergenerational associations between parental ideal health behaviors and offspring ideal health behaviors using the **meologit** command in Stata. Offspring health behaviors were measured three times (in 2001, 2007 and

2011) so that each participant could contribute one, two or three person-observations to the multilevel dataset (n=1475 in 2001, n=1373 in 2007, n=1022 in 2011). We examined the associations of parental ideal health behaviors with offspring ideal behaviors adjusting for sex, birth year, age, parental education and an interaction term between single-parenthood and parental health behaviors to account for the lower total number of parental health behaviors in single-parent families. We illustrated these results by calculating predicted probabilities of offspring having three or four ideal behaviors (vs fewer) at the 10th and 90th percentile cutoff points of the number of parental ideal health behaviors (i.e. at values 1 and 6). Also, we separately evaluated the associations of both mother's and father's health behaviors with offspring health behaviors in mutually adjusted models. To assess whether the intergenerational associations differed across levels of SEP, we conducted a test for the linear component of trend by including an interaction term between the number of parental ideal health behaviors and SEP in the adjusted models that also included the main effects of parental ideal health behaviors and SEP. These tests for linear trend were conducted in separate models for offspring and parental SEP. Similarly to offspring health behaviors, offspring SEP was measured in 2001, 2007 and 2011 (except income measured in 2007 and 2011). To illustrate the interaction effects, we plotted the odds ratios (OR) for the associations between parental ideal health behaviors and offspring ideal behaviors stratified on levels of SEP. In these models, educational attainment was used as a primary measure of SEP because it remains relatively stable over time and is an indicator of SEP that is strongly associated with health behaviors and cardiovascular outcomes.[16,30,31] In addition, we separately evaluated the intergenerational associations of health behaviors across mother's and father's educational attainment in mutually adjusted models and compared these interaction effects using the Wald test. We also ran the interaction models using income and occupational status as indicators of SEP.

We conducted additional analyses evaluating the relationship between the number of parental ideal health behaviors and the number of ideal behaviors among offspring modeled as a continuous linear outcome. For these analyses, we used random-intercept linear multilevel regression using the **xtreg** command in Stata and plotted the marginal linear predictions for the number of offspring ideal health behaviors at quintiles of parental health behaviors across different levels of SEP. As a sensitivity analysis, we repeated all analyses with a restricted sample that only comprised two-parent families.

Offspring having four ideal behaviors (vs zero) and higher SEP had smaller attrition in each consecutive follow-up in adulthood. Attrition across follow-ups in 2001, 2007 and 2011 was also associated with parental SEP except income, and with parental smoking and BMI (see Supplemental Material Tables 2-3). To account for selective attrition, we used pattern mixture modeling.[32] We adjusted all analyses for an attrition indicator expressing the number of times a participant did not contribute to the analysis during the adulthood follow-ups in 2001, 2007 and 2011.

All analyses were conducted with Stata 13.1 (StataCorp, LP, College Station, TX, USA).

RESULTS

Supplemental Material Tables 4-5 show the characteristics of participants and their parents. Among participants, there were 1021 (55.0%) women. In 2001, mean age was 31.1 (SD, 5.0), and participants met an average of 2.0 (1.1) ideal health behaviors. Distributions of all health behaviors among parents and offspring are presented in Supplemental Material, Table 6. Repeated measurements of health behaviors and indicators of SEP were strongly or moderately correlated over the follow-up (see Supplemental Material Table 7).

In multilevel ordinal logistic regression models adjusted for the attrition indicator, offspring sex, birth year, age, parental education and the interaction between single-parenthood and parental health behaviors, parental ideal health behaviors were associated with ideal behaviors among offspring (OR=1.28 for each additional ideal behavior among offspring, 95% CI: 1.17, 1.39). Predicted probabilities of offspring having three or four ideal behaviors (vs fewer) were 11.0% at the 10^{th} percentile and 27.1% at the 90^{th} percentile of parental ideal behaviors. The intergenerational associations of ideal health behaviors were of similar magnitude between both mothers and offspring (OR=1.30, 95% CI: 1.10,1.52) and fathers and offspring (OR=1.25, 95% CI: 1.09, 1.45). Intergenerational associations of each behavior separately are presented in Supplemental Material, Table 8.

The odds ratios for the associations between parental ideal behaviors and offspring ideal behaviors were greater for offspring with higher educational attainment (Figure 1) or whose parents had higher educational attainment (Figure 2) than for those with lower educational attainment (*p* for interaction=0.02 (offspring education), *p* for interaction=0.01 (parental education)). Furthermore, the differences in intergenerational associations across both mother's and father's educational attainment were similar ($p_{\text{Wald heterogeneity}}$=0.45). The association between parental ideal health behaviors and offspring health behaviors did not vary across levels of offspring income (Figure 1, *p* for interaction=0.37), but seemed to be stronger at higher levels of parental income (Figure 2, *p* for interaction=0.06). The association of parental health behaviors with offspring health behaviors was also stronger among offspring with higher occupational status (Figure 1, *p* for interaction=0.08). However, this trend was not consistently apparent with parental occupational status (Figure 2, *p* for interaction=0.21).

(Figures 1 and 2)

Similarly, in linear multilevel regression each one-unit increase in parental ideal health behaviors (equivalent to one additional ideal behavior in either parent) was associated with 0.08 (95% CI: 0.05, 0.11) units higher ideal behaviors among offspring after adjustments. These intergenerational associations were also greater among offspring with higher educational attainment (*p* for interaction=0.02) or whose parents had higher educational attainment (*p* for interaction=0.007) (Figure 3). Likewise, the intergenerational associations tended to be greater at higher levels of parental income (*p* for interaction=0.05) and offspring occupational status (*p* for interaction=0.07), but they did not differ across levels of offspring income (*p* for interaction=0.34) or parental occupational status (*p* for interaction=0.15).

(Figure 3)

All results were similar in analyses restricting the study population to participants from two-parent families (n=1670).

DISCUSSION

In this prospective intergenerational cohort study, higher number of ideal health behaviors among parents was associated with higher number of ideal behaviors among their adult offspring assessed over two decades later. Furthermore, the intergenerational associations of ideal behaviors between parents and offspring were greater for participants with higher own or parental educational attainment. Although findings with two other indicators of SEP showed a less consistent pattern of interaction, we also observed greater intergenerational associations at higher levels of parental income and offspring occupational status.

Several studies have demonstrated associations of parental health behaviors with offspring health behaviors,[5–8,10] most of them focusing on single behavioral risk markers. Health behaviors are often clustered within people and studies have shown that the simultaneous presence of several healthy behaviors is relevant to cardiovascular outcomes.[2,3] By examining simultaneously a set of health behaviors, we were able to account for this clustering of behaviors within individuals and assess the intergenerational associations of an overall behavioral risk of cardiovascular disease.

Few previous studies have evaluated the role of SEP in influencing intergenerational patterns of health behaviors and the results are not conclusive.[7,22,23] A study in the National Longitudinal Survey of Youth reported greater intergenerational persistence of high BMI among participants with higher parental educational attainment.[23] Another study using three nationally representative US samples observed no interaction effects with education when examining intergenerational associations of BMI.[22] By contrast, Næss et al. (2016) reported weaker associations of parental overweight with offspring BMI in strata of higher parental education in a Norwegian cohort.[7] Similarly, in our data, Serlachius et al. (2016) showed that social support in adulthood was protective against the intergenerational risk for higher BMI.[33]

We found evidence to support our hypothesis that higher levels of educational attainment – in parents and their offspring – strengthen the protective intergenerational associations. A corresponding pattern of interaction emerged also with parental income and offspring occupational status, but not with offspring income and parental occupational status. Higher educational attainment has been associated with greater human capital, effective agency and sense of personal control, more extensive health-related knowledge and better psychological capability to act on this knowledge.[16,19] Such factors may be particularly important to an individual's ability to promote and maintain healthy behaviors.[16] The most consistent pattern of interaction observed with education also likely reflects education remaining most stable over time of the indicators of SEP we assessed.

In general, higher SEP may involve financial access to healthy lifestyles and residence in neighborhoods promoting healthy behavioral options, more social support and less environmental stress.[15,28,34] Parental socioeconomic advantage can thus help create a developmental environment supporting optimal behaviors that has a lasting influence on offspring health behaviors, and also reduce the chance of parents passing on their non-ideal behaviors to their offspring. Attaining higher SEP in adulthood, in turn, can provide people with more opportunities to sustain lifestyles adopted earlier in life. Higher SEP may also enhance a person's capability to access and use heath information.[16,19] Healthy behaviors of parents are one source of health promotion and people with higher SEP may more likely adhere to such examples. Finally, the intergenerational associations of health behaviors may involve genetic determinants. Our design was not genetically informative, but our findings may reflect higher SEP strengthening protective genetic associations. Such gene-environment interaction effects have been recently suggested by studies assessing the genetic risk for higher BMI.[35,36]

This study has limitations. Our data is from a long-standing cohort study where loss to follow-up is inevitable. Although we used pattern mixture modeling to account for selective attrition, attrition might have biased the observed associations. Like any observational study, we cannot rule out the possibility of unmeasured or residual confounding. However, we controlled for a set of potential confounders that were selected *a priori* based on their known or hypothesized relationships to the relevant exposures, outcomes and other covariates. The adult FFQs used in this study have been validated in the Finnish population[13,37] and the dietary measures in childhood and adulthood have been associated with cardiovascular risk factors and outcomes.[38,39] Still, dietary intake could be incorrectly estimated due to assumptions of the food composition database or reporting bias. Self-reported measures of physical activity are potentially subject to reporting bias, however, the physical activity questionnaire used in this study has been shown to have acceptable convergent validity against objectively assessed pedometric data among Finnish adults.[40] The study participants were a cohort of predominantly white, ethnically homogeneous people residing in Finland, which may limit the generalizability of our results. The strengths of our study include repeated measurement of health behaviors and SEP in adulthood and prospective assessment of parental SEP and health behaviors in 1980. We obtained similar results from linear and ordinal logistic analyses, indicating that our findings were robust and not contingent on analytical approach.

In conclusion, we observed that parents' ideal health behaviors were associated with ideal behaviors of their adult offspring. These intergenerational associations were greater among those with higher socioeconomic position in childhood or adulthood, suggesting that socioeconomic advantage strengthens the intergenerational continuity of ideal health behaviors. Intergenerational associations of health behaviors represent one mechanism explaining long-term trends in population cardiovascular health, and our results suggest upward social mobility may help counteract the continuity of behavioral risk factors occurring across generations. Further work is needed to evaluate these associations in other populations, elucidate underlying mechanisms and assess the relevance of these findings to cardiovascular health promotion.

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Conflict of Interest: The authors declare that there is no conflict of interest.

Author contributions: All authors contributed to the concept and design of the work. KK, MAM, MJo and LPR conducted the statistical analysis and KK, MAM, MJo, LKJ and LPR interpreted the findings. TL, KP, TT, ME, MJu, OR, LKJ and LPR contributed to data acquisition. KK drafted the manuscript, and all authors critically revised the manuscript. All gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

Research ethics and patient consent: This study was reviewed and approved by the Ethics Committee of the Hospital District of Southwest Finland and Harvard T.H. Chan School of Public Health Office of Human Research Administration.

References

1. Lloyd-Jones DM, Hong Y, et al. Defining and setting national goals for cardiovascular health promotion and disease reduction: The American Heart Association's Strategic Impact Goal through 2020 and beyond. *Circulation* 2010; 121: 586–613.
2. Chiuve SE, Rexrode KM, et al. Primary prevention of stroke by healthy lifestyle. *Circulation* 2008; 118: 947.
3. Stampfer MJ, Hu FB, et al. Primary prevention of coronary heart disease in women through diet and lifestyle. *N Engl J Med* 2000; 343: 16–22.
4. Eliasson M, Eriksson M, et al. Comparison of trends in cardiovascular risk factors between two regions with and without a community and primary care prevention programme. *Eur J Prev Cardiol* 2018; 25: 1765–1772.
5. Wickrama KAS, Conger RD, et al. The intergenerational transmission of health-risk behaviors: Adolescent lifestyles and gender moderating effects. *J Health Soc Behav* 1999; 40: 258–272.
6. Savage JS, Fisher JO, Birch LL. Parental influence on eating behavior. *J Law Med Ethics* 2007; 35: 22–34.
7. Næss M, Holmen TL, et al. Intergenerational transmission of overweight and obesity from parents to their adolescent offspring - The HUNT study. *PLoS One* 2016; 11: 1–14.
8. Kaseva K, Hintsa T, et al. Parental physical activity associates with offspring's physical activity until middle age: A 30-year study. *J Phys Act Heal* 2017; 14: 520–531.
9. Gilman SE, Rende R, et al. Parental smoking and adolescent smoking initiation: An intergenerational perspective on tobacco control. *Pediatrics* 2009; 123: 1–14.
10. Dhana K, Haines J, et al. Association between maternal adherence to healthy lifestyle practices and risk of obesity in offspring: results from two prospective cohort studies of mother-child pairs in the United States. *BMJ*. Epub ahead of print 8 May 2018. DOI: 10.1136/bmj.k2486.

11. Chassin L, Presson, Clark C, et al. The natural history of cigarette smoking from adolescence to adulthood: Demographic predictors of continuity and change. *Health Psychol* 1996; 15: 478–484.

12. Singh AS, Mulder C, et al. Tracking of childhood overweight into adulthood: A systematic review of the literature. *Obes Rev* 2008; 9: 474–488.

13. Mikkilä V, Räsänen L, et al. Consistent dietary patterns identified from childhood to adulthood: The Cardiovascular Risk in Young Finns Study. *Br J Clin Nutr* 2005; 52: 923–931.

14. Telama R. Tracking of physical activity from childhood to adulthood: A review. *Obes Facts* 2009; 2: 187–195.

15. Lynch, JW, Kaplan, GA, Salonen J. Why do poor people behave poorly? Variation in adult health behaviors and psychosoocial characteristics by stages of the socioeconomic life course. *Soc Sci Med* 1997; 44: 809–819.

16. Pampel FC, Krueger P, Denney J. Socioeconomic disparities in health behaviors. *Annu Rev Sociol* 2010; 36: 349–370.

17. Pulkki-Råback L, Elovainio M, et al. Cumulative effect of psychosocial factors in youth on ideal cardiovascular health in adulthood the cardiovascular risk in young Finns study. *Circulation* 2015; 131: 245–253.

18. Stringhini S, Sabia S, et al. Association of socioeconomic position with health behaviors and mortality. *JAMA* 2010; 303: 1159–1166.

19. de Waard A-KM, Wändell PE, et al. Barriers and facilitators to participation in a health check for cardiometabolic diseases in primary care: A systematic review. *Eur J Prev Cardiol* 2018; 25: 1326–1340.

20. Gallo LC, de los Monteros KE, Shivpuri S. Socioeconomic status and health: What is the role of reserve capacity? 2009; 18: 269–274.

21. Matthews KA, Gallo LC, Taylor SE. Are psychosocial factors mediators of socioeconomic status and health connections? *Ann N Y Acad Sci* 2010; 1186: 146–173.

22. Thompson O. The intergenerational transmission of health status: Estimates and mechanisms. *The Society of Labor Economists*, http://www.sole-jole.org/13231.pdf (2013, accessed 25 March 2018).

23. Classen TJ. Measures of the intergenerational transmission of body mass index between mothers and their children in the United States, 1981–2004. *Econ Hum Biol* 2010; 8: 30–43.

24. Raitakari OT, Juonala M, et al. Cohort profile: The cardiovascular risk in young Finns study. *Int J Epidemiol* 2008; 37: 1220–1226.

25. Laitinen TT, Pahkala K, et al. Ideal cardiovascular health in childhood and cardiometabolic outcomes in adulthood: The Cardiovascular Risk in Young Finns Study. *Circulation* 2012; 125: 1971–1978.

26. Laitinen TT, Pahkala K, et al. Lifetime measures of ideal cardiovascular health and their association with subclinical atherosclerosis: The Cardiovascular Risk in Young Finns Study. *Int J Cardiol* 2015; 185: 186–191.

27. Bowles S, Gintis H. The inheritance of inequality. *J Econ Perspect* 2002; 16: 3–30.

28. Lynch J, Kaplan G. Socioeconomic position. In: Berkman LF, Kawachi I (eds) *Social epidemiology*. NY: Oxford University Press, 2000, pp.13–36.

29. Lawlor DA, Batty GD, et al. Childhood socioeconomic position, educational attainment, and adult cardiovascular risk factors: The Aberdeen Children of the 1950s Cohort Study. *Am J Public Health* 2005; 95: 1245–1251.

30. Kilander L, Berglund L, et al. Education, lifestyle factors and mortality from cardiovascular disease and cancer. A 25-year follow-up of Swedish 50-year-old men. *Int J Epidemiol* 2001; 30: 1119–1126.

31. Winkleby M, Jatulis D. Socioeconomic status and health: How education, income, and occupation contribute to risk factors for cardiovascular disease. *Am J Public Health* 1992; 82: 816–20.

32. Hedeker D, Gibbons RD. Application of random-effects pattern-mixture models for missing data in longitudinal studies. *Psychol Methods* 1997; 2: 64–78.

33. Serlachius A, Elovainio M, et al. High perceived social support protects against the intergenerational transmission of obesity: The Cardiovascular Risk in Young Finns Study. *Prev Med (Baltim)* 2016; 90: 79–85.

34. Chen E, Miller GE. Socioeconomic status and health: Mediating and moderating factors. *Annu Rev Clin Psychol* 2013; 9: 723–49.

35. Tyrrell J, Wood AR, et al. Gene–obesogenic environment interactions in the UK Biobank study. *Int J Epidemiol* 2017; 46: 559–575.

36. Walter S, Mejía-Guevara I, et al. Association of a genetic risk score with body mass index across different birth cohorts. *JAMA* 2016; 316: 63–69.

37. Kaartinen NE, Tapanainen H, et al. Relative validity of a FFQ in measuring carbohydrate fractions, dietary glycaemic index and load: exploring the effects of subject characteristics. *Br J Nutr* 2012; 107: 1367–1375.

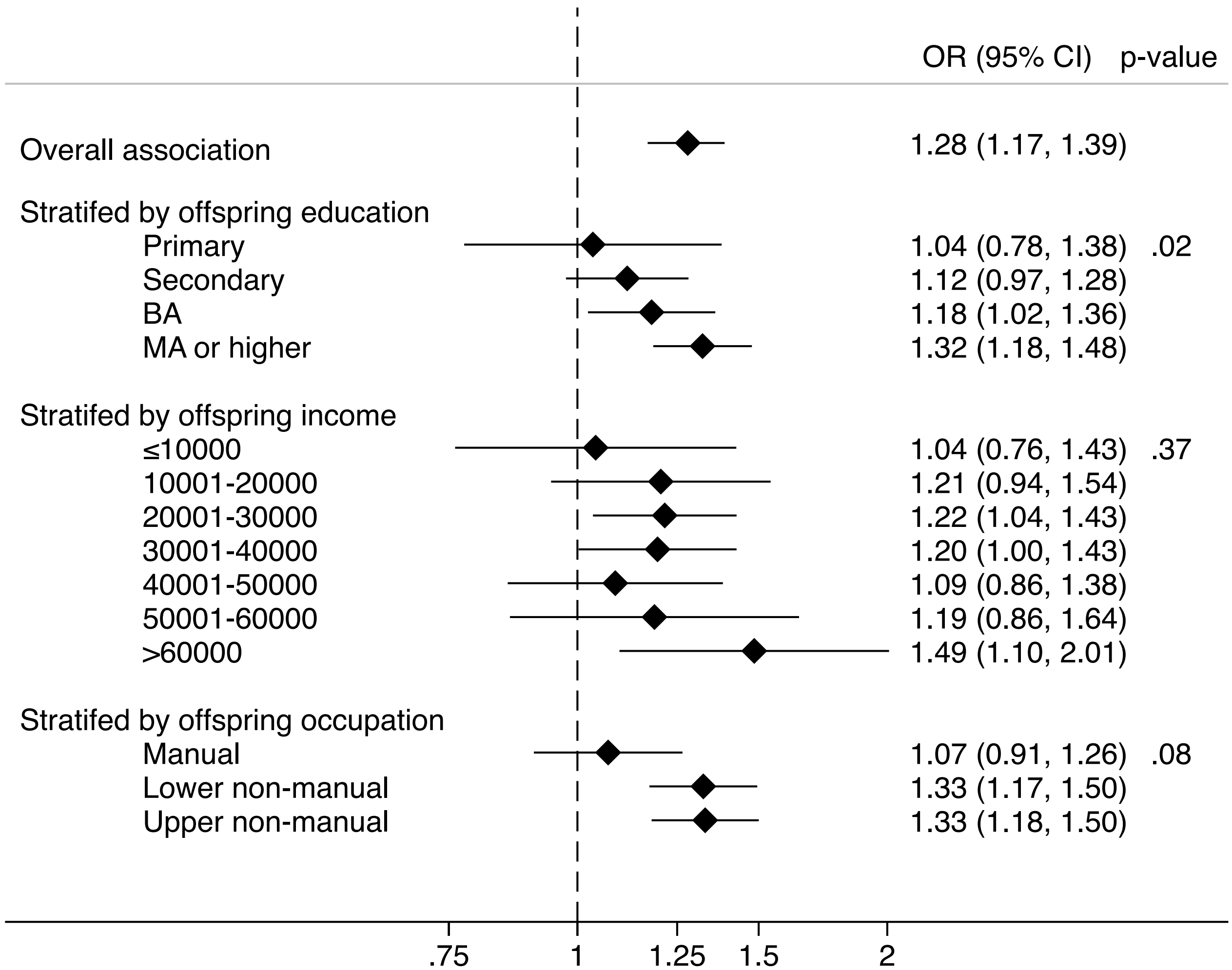
38. Nissinen K, Mikkilä V, et al. Sweets and sugar-sweetened soft drink intake in childhood in relation to adult BMI and overweight. The Cardiovascular Risk in Young Finns Study. *Public Health Nutr* 2009; 12: 2018–2026.

39. Aatola H, Koivistoinen T, et al. Lifetime Fruit and Vegetable Consumption and Arterial Pulse Wave Velocity in Adulthood. *Circulation* 2010; 122: 2521–2528.

40. Hirvensalo M, Magnussen CG, et al. Convergent Validity of a Physical Activity Questionnaire against Objectively Measured Physical Activity in Adults: The Cardiovascular Risk in Young

Finns Study. *Adv Phys Educ* 2017; 07: 457–472.

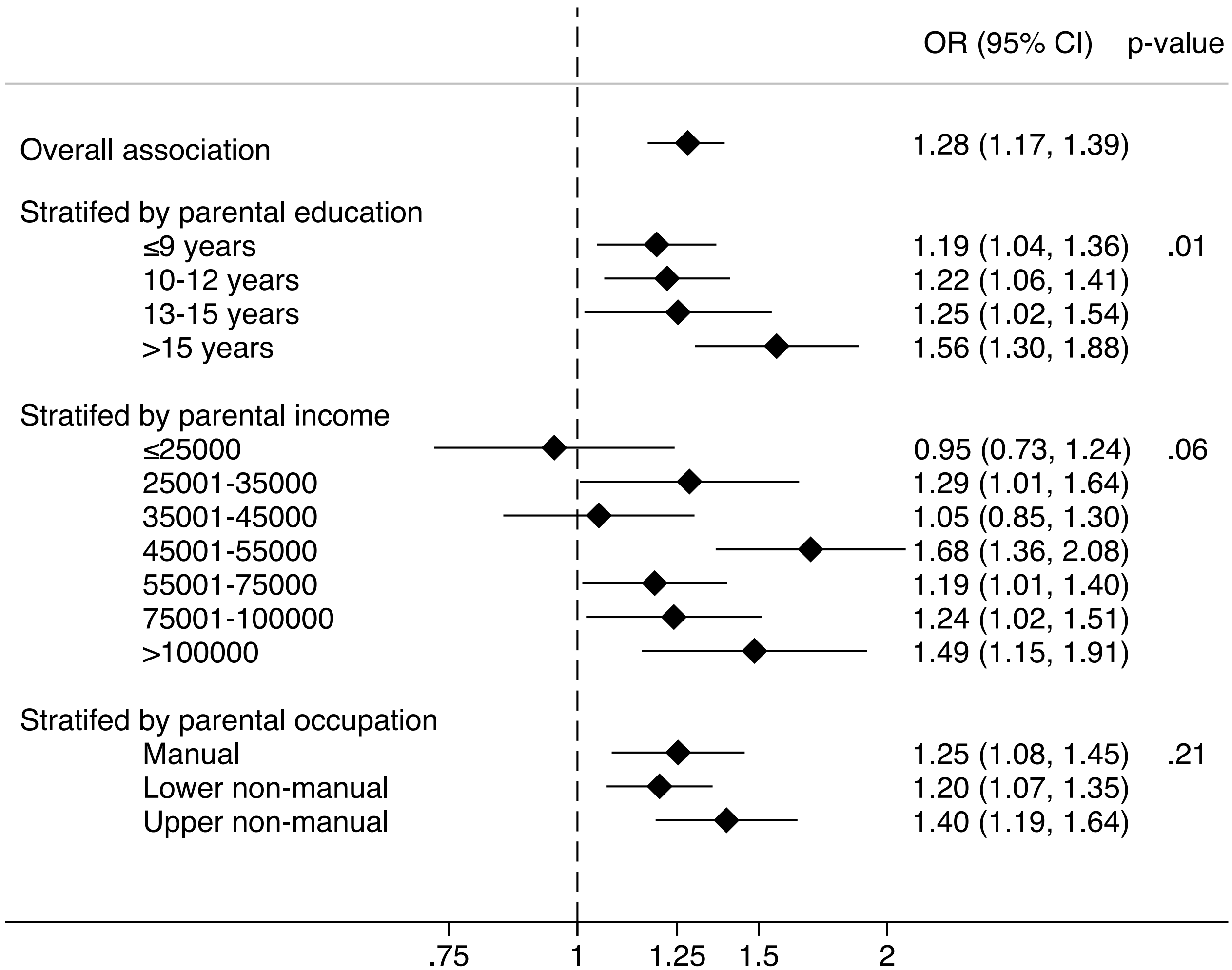
Figure 1. Odds ratios for associations of parental ideal health behaviors with ideal health behaviors among offspring stratified by offspring SEP in the Cardiovascular Risk in Young Finns Study



Abbreviations: SEP, socioeconomic position; BA, Bachelor's degree; MA, Master's degree; EUR, euro.

Adjusted for the attrition indicator, sex, birth year, age, parental educational attainment and the interaction effect between the number of parental health behaviors and single-parenthood. Horizontal lines represent the 95% confidence intervals.

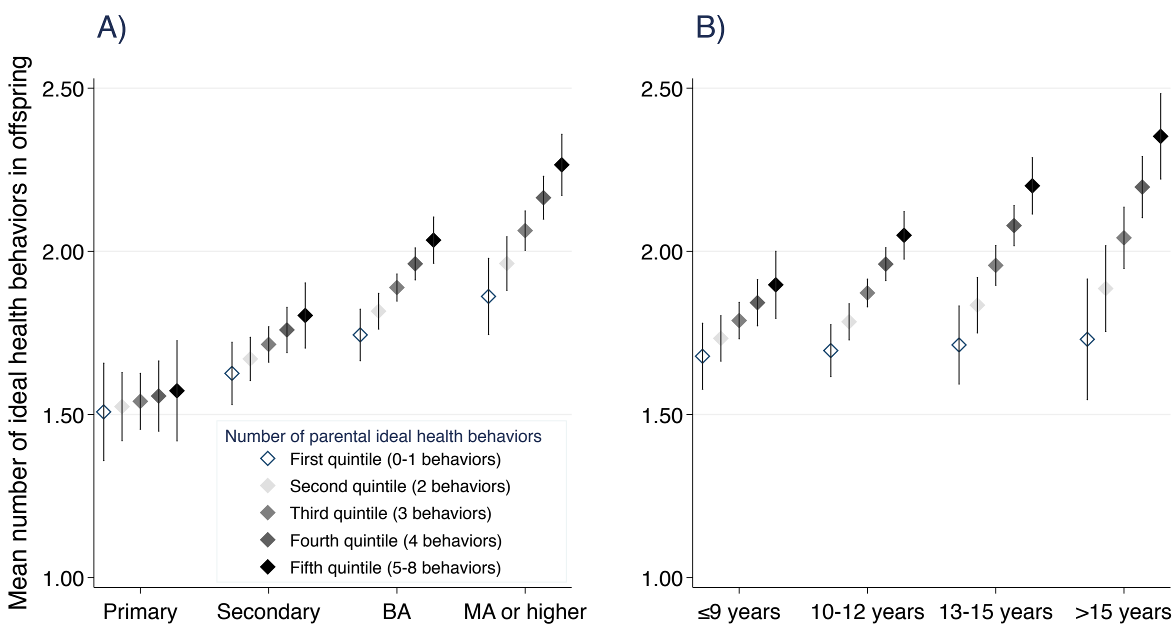
Figure 2. Odds ratios for associations of parental ideal health behaviors with ideal health behaviors among offspring stratified by parental SEP in the Cardiovascular Risk in Young Finns Study



Abbreviations: SEP, socioeconomic position; FIM, Finnish mark.

Adjusted for the attrition indicator, sex, birth year, age and the interaction effect between the number of parental health behaviors and single-parenthood. Horizontal lines represent the 95% confidence intervals. Parental income measured as household gross income (FIM) in 1979.

Figure 3. Mean number of offspring ideal health behaviors associated with parental health behaviors at different levels of A) offspring and B) parental educational attainment in the Cardiovascular Risk in Young Finns Study



Abbreviations: BA, Bachelor’s degree; MA, Master’s degree.

Adjusted for the attrition indicator, sex, birth year, age and the interaction effect between the number of parental health behaviors and single-parenthood. Second panel additionally adjusted for parental educational attainment. Vertical lines represent the 95% confidence intervals.

List of supplemental material for Socioeconomic position and intergenerational associations of ideal health behaviors by Kaisla Komulainen, Murray A. Mittleman, Markus Jokela, Tomi T. Laitinen, Katja Pahkala, Marko Elovainio, Markus Juonala, Tuija Tammelin, Mika Kähönen, Olli Raitakari, Liisa Keltikangas-Järvinen and Laura Pulkki-Råback in the *European Journal of Preventive Cardiology*

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SUPPLEMENTAL DATA FILE

Socioeconomic position and intergenerational associations of ideal health behaviors

Supplemental table 1. Measurement times for parental and offspring variables

	1980	2001	2007	2011
Parental measurements				
Health behaviors	x			
Education	x			
Income	x			
Occupation	x			
Offspring measurements[a]				
Health behaviors		x	x	x
Education		x	x	x
Income			x	x
Occupation		x	x	x

[a]Each participant could contribute one, two or three person-observations to the multilevel dataset (n=1475 in 2001, n=1373 in 2007, n=1022 in 2011).

Supplemental table 2. Associations of offspring ideal health behaviors and socioeconomic position with attrition in consecutive follow-ups

		OR	95% CI		p
Non-smoking		0.52	0.40	0.66	0.000
BMI < 25 kg/m^2		0.95	0.75	1.22	0.696
Ideal physical activity		0.80	0.65	0.99	0.039
Ideal diet		0.60	0.41	0.89	0.011
Total number of ideal health behaviors					
	0 (Ref)	1.00	.	.	.
	1	1.44	0.62	3.31	0.396
	2	0.75	0.32	1.79	0.520
	3	0.55	0.22	1.41	0.214
	4	0.29	0.08	1.01	0.052
Educational attainment		0.70	0.62	0.79	0.000
Income[a]		0.92	0.87	0.98	0.010
Occupational status		0.86	0.73	1.01	0.064

Abbreviations: OR, odds ratio, CI, confidence interval, BMI, body mass index
All estimates are sex- and age-adjusted estimates from random-intercept multilevel logistic regression models.
Attrition is a time-varying outcome assessed in 2007 and 2011.
All exposures are time-varying exposures measured in 2001 and 2007 unless otherwise noted.
[a]Based on simple logistic regression regressing attrition in 2011 on income in 2007.

Supplemental table 3. Associations of parental ideal health behaviors and socioeconomic position with attrition across follow-ups in 2001, 2007 and 2011

	OR	95% CI		p
Non-smoking	0.54	0.46	0.64	0.000
BMI < 25 kg/m^2	0.85	0.71	1.01	0.065
Ideal physical activity	0.85	0.69	1.05	0.126
Ideal diet	0.91	0.71	1.15	0.423
Total number of ideal health behaviors	0.94	0.89	1.00	0.051
Educational attainment	0.62	0.54	0.71	0.000
Income	0.95	0.86	1.04	0.273
Occupation	0.68	0.58	0.81	0.000

Abbreviations: OR, odds ratio; CI, confidence interval; BMI, body mass index
Total number of parental ideal health behaviors is a continuous exposure ranging from 0 to 8.
All estimates are unadjusted estimates from random-intercept multilevel logistic regression models.
Attrition across 2001, 2007 and 2011 is a time-varying outcome.

Supplemental table 4. Characteristics of Parents of 1856 Participants in the Cardiovascular Risk in Young Finns Study

	Mean (SD)	N[%]
Parental educational attainment (years) in 1980	10.9 (3.7)	
Household gross income in 1979 (FIM)	4.0 (1.8)	
≤25000		223 [12.3%]
25001-35000		198 [10.9%]
35001-45000		283 [15.6%]
45001-55000		283 [15.6%]
55001-75000		405 [22.4%]
75001-100000		271 [15.0%]
>100000		149 [8.2%]
Parental occupational status in 1980		
Manual		667 [36.4%]
Lower non-manual		809 [44.2%]
Higher non-manual		355 [19.4%]
Number of parental ideal health behaviors[a]	3.3 (1.6)	

Abbreviations: SD, standard deviation; FIM, Finnish mark.
N=1856 persons (3870 person-observations across three study phases).
[a]The number of parental ideal health behaviors ranges from 0 to 8.

Supplemental table 5. Characteristics of 1856 Participants in the Cardiovascular Risk in Young Finns Study

		Mean (SD)	N[%][a]
Sex (female)			1021 [55.0%]
Age in 2001		31.1 (5.0)	
Single-parent family			186 [10.0%]
Study phases with missing data			
	None		1176 [63.4%]
	1		451 [24.3%
	2		229 [12.3%]
Offspring education in 2001		1.8 (0.9)	
	Primary		90 [6.1%]
	Secondary		534 [36.2%]
	BA		419 [28.4%]
	MA or higher		432 [29.3%]
Offspring gross income in 2007 (EUR)		3.5 (1.4)	
	≤10000		96 [7.3%]
	10001-20000		185 [14.0%]
	20001-30000		481 [36.3%]
	30001-40000		291 [22.0%]
	40001-50000		141 [10.6%]
	50001-60000		61 [4.6%]
	>60000		70 [5.3%]
Offspring occupational status in 2001			
	Manual		358 [26.9%]
	Lower non-manual		588 [44.1%]
	Higher non-manual		387 [29.0%]
Number of offspring ideal health behaviors in 2001[b]		2.0 (1.1)	

Abbreviations: SD, standard deviation; EUR, euro; BA, Bachelor's degree; MA, Master's degree.
N=1856 persons (3870 person-observations across three study phases).
Time-varying data calculated at the follow-up baseline in 2001 (n=1475), except for income in 2007 (n=1373).

[a]Not all numbers in time-varying data add up to 1475 or 1373 due to missingness (missing income in 2007 n=48, missing occupational status in 2001=142). Of the 1856 participants, 320 and 108 did not contribute to the analysis with offspring income and occupational status due to missingness in 2001, 2007 and 2011, and 44 and 25 did not contribute to the analysis with parental income and parental occupational status due to missingness in 1980.

[b]The number of offspring ideal health behaviors ranges from 0 to 4.

Supplemental table 6. Distributions of ideal behaviors among parents and offspring in the Cardiovascular Risk in Young Finns Study

Parents in 1980		N [%]	**Offspring across the follow-up**		N [%]
Non-smoking	Neither parent	293 [15.8%]	Non-smoking	2001	991 [67.2%]
	One parent	678 [36.5%]		2007	1010 [73.6%]
	Both parents	885 [47.7.%]		2011	825 [80.7%]
BMI < 25 kg/m^2	Neither parent	358 [19.3%]	BMI < 25 kg/m^2	2001	841 [57.0%]
	One parent	900 [48.5%]		2007	641 [46.7%]
	Both parents	598 [32.2%]		2011	462 [45.2%]
Ideal physical activity	Neither parent	1321 [71.2%]	Ideal physical activity	2001	807 [54.7%]
	One parent	410 [22.1%]		2007	721 [52.5%]
	Both parents	125 [6.7%]		2011	609 [59.6%]
Ideal diet[a]	No	1412 [76.1%]	Ideal diet[b]	2001	360 [24.4%]
	Yes	444 [23.9%]		2007	87 [6.3%]
				2011	61 [6.0%]
Total number of ideal health behaviors in 1980	0	35 [1.9%]	Total number of ideal health behaviors at the follow-up baseline in 2001	0	104 [7.1%]
	1	183 [9.9%]		1	384 [26.0%]
	2	430 [23.2%]		2	479 [32.5%]
	3	441 [23.8%]		3	375 [25.4%]
	4	366 [19.7%]		4	133 [9.0%]
	5	218 [11.8%]			
	6	125 [6.7%]			
	7	42 [2.3%]			
	8	16 [0.9%]			

[a]Offspring diet in 1986 was used as a proxy for family food environment.
[b]The criterion for ideal diet was different in 2001 (2/3 ideal components) and 2007/2011 (4/5 ideal components) due to differences in measurement.
The eligible sample included 1856 individuals. N differs across adult follow-ups due to available data (n=1475 in 2001, n=1373 in 2007 and n=1022 in 2011).

Supplemental table 7. Intraclass correlations for the repeated measurements of offspring health behaviors and socioeconomic position across 2001, 2007 and 2011

	ICC
Non-smoking	0.94
BMI < 25 kg/m^2	0.84
Ideal physical activity	0.49
Ideal diet[a]	0.56
Total number of ideal health behaviors	0.56
Educational attainment	0.85
Income[b]	0.76
Occupational status	0.78

Abbreviations: ICC, intraclass correlation, BMI, body mass index
Based on multilevel logistic and linear regression models.
[a]ICC for diet calculated based on measurements in 2007 and 2011 due to a difference in scale in 2001 measurement.
[b]ICC for income based on measurements in 2007 and 2011.

Supplemental table 8. Predicted probabilities of each ideal behavior among offspring by parental ideal behavior

	Number of parents with ideal behavior			
	0	1	2	OR
Non-smoking	62.3 %	71.1 %	78.5 %	1.54 (1.34, 1.77)
BMI < 25 kg/m^2	36.7 %	47.4 %	58.4 %	1.64 (1.44, 1.88)
Ideal physical activity	53.4 %	57.1 %	60.7 %	1.21 (1.06, 1.38)
Ideal diet[a]	10.4 %	14.4 %	-	1.53 (1.22, 1.93)

Abbreviations: BMI, body mass index

[a]Offspring diet in 1986 used as a proxy for family food environment (ideal vs non-ideal).

All predicted probabilities are from population-averaged random-intercept multilevel logistic regression models.