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Do family characteristics contribute to a socioeconomic gradient in overweight in early childhood? – Single mediation analyses of data from German preschool children

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ABSTRACT

Children's overweight is strongly associated with family socioeconomic position (SEP) and family characteristics (FC). There is limited research on the extent to which FC account for a socioeconomic gradient in childhood overweight. This study examined whether FC explain SEP differences in the prevalence of overweight. The study used baseline data of preschool-aged children from the German 'PReschool INtervention Study'. The sample (n = 872, 48% girls) was recruited at kindergartens in Baden-Württemberg, Germany. Data included children's measured weight status and parents' reports on socioeconomic indicators (e.g., school education, vocational education, income) and FC. Variables represent main determinants of overweight (nutrition: sweets consumption in front of TV, soft drink consumption, regular breakfast, child sets table; physical activity: outdoor sports; parental role model). In single mediation analyses indirect effects of SEP on overweight were analysed (OR[95% CI]). Preschool girls and boys with low parental education had higher odds for overweight than children with high parental education. Among boys, low levels of parental education contributed to the odds of overweight via indirect effects by both factors 'sweets consumption in front of TV' (OR = 1.31[1.05–1.59]) and 'no sports' (OR = 1.14[1.01–1.38]). Among girls, FC measured did not explain SEP differences in overweight. Family nutrition and parental/family physical activity contribute to inequalities in overweight among preschool boys, but not girls. Research is needed to identify FC that explain inequalities in overweight for both.

1. Introduction

The prevalence of overweight in early childhood – operationalized as the life span from birth to six years – has increased considerably in recent decades (Jaacks et al., 2019). In 2020, 39 million children under the age of five were overweight (WHO, 2021), with differences according to individual characteristics and life circumstances. In particular, overweight is more common in boys than in girls. Shah et al. (2020) suggest possible associations related to both i) differences in body composition, fetal growth, and hormones (i.e., sex differences) and ii) social values about body weight and parental feeding practices (i.e., gender differences). Furthermore, extensive evidence demonstrates that the prevalence of childhood overweight is largely associated with socioeconomic position of the family (family SEP for short). For example, socioeconomic disadvantages related to parental education or household income are associated with obesity and overweight among older children and adolescents (Ahrens et al., 2014; Bailey-Davis et al., 2012; Bates et al., 2018; Chung et al., 2016; Freedman et al., 2007; Shrewsbury

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and Wardle, 2008). A less clear picture emerges when early childhood is considered. Still, some studies corroborate socioeconomic differences in the prevalence of overweight by using a joint family SEP index (3–6 years old children) (Schienkiewitz et al., 2019), or by separate consideration of maternal and paternal highest level of education obtained (2, 4 and 6 years old children) (Iguacel et al., 2018). Nonetheless, other studies did not find any differences in overweight in early childhood by parental education (Bürgi et al., 2010). Therefore, there is inconclusive evidence regarding the presence of a socioeconomic gradient in early childhood overweight. In addition, research shows that the relationship between family SEP and health tends to be cumulative with "tangible effects" occurring later on in life (Gerhardstein et al., 2012). Thus, socioeconomic inequalities in childhood overweight may not be apparent in early childhood, as known determinants of overweight (e.g., children's eating behaviours) may operate throughout childhood across the life span (Birch and Ventura, 2009; Pigeot et al., 2016). However, the early childhood period contributes to preconditions for socioeconomic inequalities in overweight for the following reasons (Birch and Ventura, 2009). The natural growth of body mass index (BMI), which is used as a proximal measure of overweight based on sex-specific percentile growth charts, decreases between the ages of three and seven (Boonpleng et al., 2013), while the timing differs based on the family SEP (Kang, 2018). Children from socioeconomically disadvantaged families may have a higher risk of overweight across the life course (Poulsen et al., 2018) as the BMI decrease occurs earlier in life (Kang, 2018).

The pathways by which family SEP affects children's overweight are complex (Davison and Birch, 2001). Ecological approaches postulate that people with their genetics and biographical influences are embedded in different contexts, each with specific resources and burdens for health. In early childhood, the child's family is the first and most important context experienced (Boonpleng et al., 2013) that "determines many of the biological, environmental, and social pressures" (Lawlor and Mishra, 2009, p. 10). Families are defined by related members of at least two generations (Evertsson et al., 2021). Their processes, including their behaviours and routines, might contribute to children's weight in early childhood. For example, family nutrition behaviour (i.e., meal time regularity, breastfeeding) or family physical activity as well as parental and children's screen time are associated with overweight and obesity among 2–6 years old children (Ang et al., 2013; Danielzik et al., 2004; Moraeus et al., 2012; Watanabe et al., 2016; Wen et al., 2014). Recent literature found that the theoretical framework of the family investment model (FIM) and parental role models might be helpful for examining socioeconomic health inequalities (Blume et al., 2021; Hoffmann et al., 2022).

There is limited research on the extent to which family processes mediate socioeconomic inequalities in early childhood overweight (Hoffmann et al., 2022). In line with the FIM, we investigate in this study whether family investment and/or parental role models for a healthy lifestyle explain socioeconomic differences in overweight in early childhood. For this, the study aims to explore the following research questions (see Fig. 1):

- Are differences in overweight in preschool children related to parental school and vocational education and/or household income?
- Is family investment in nutrition and physical activity associated with family SEP and overweight among girls and boys?
- What is the extent to which family investment in nutrition and physical activity mediates the association between family SEP and overweight?

2. Methods

2.1. Secondary data and sample description

We used baseline data of the 'PReschool INtervention Study (PRINS)'. PRINS aimed to promote childhood health behaviour by involving the primary caregiver(s) (De Bock et al., 2010). Children were recruited (n = 1151) in 55 kindergartens in the German federal state of Baden-Württemberg. PRINS used a two-stage sampling that included kindergartens and children (De Bock et al., 2013; De De Bock et al., 2010). There were only few restrictive inclusion criteria for kindergarten selection (i.e., application for admission to PRINS, n > 15 children participating) whose characteristics are "representative of the German preschool system" (De Bock et al., 2013). All parent–child pairs were invited to participate, which supports the external validity (De Bock et al., 2010; Kendall, 2003; Moher et al., 2010). As of 1st of March 2009, 95% of the 3–6-year-old children have been cared for in day care centers in Baden-Württemberg (State statistical offices, 2010). By this, 5% of preschool aged children could not be included. Further information of PRINS have been published elsewhere (De Bock et al., 2013; De Bock et al., 2012; De Bock et al., 2010).

Data was collected (09/2008–03/2010) using measurement protocols and parental questionnaires (paper–pencil). We used cross-sectional baseline data as our individual data-based study explored predictions (associations) and not the effect of the intervention on the change in BMI scores (Faraoni and Schaefer, 2016). The Ethics Committee of the Medical Faculty Mannheim at Heidelberg University approved the original study (2008-275N-MA).

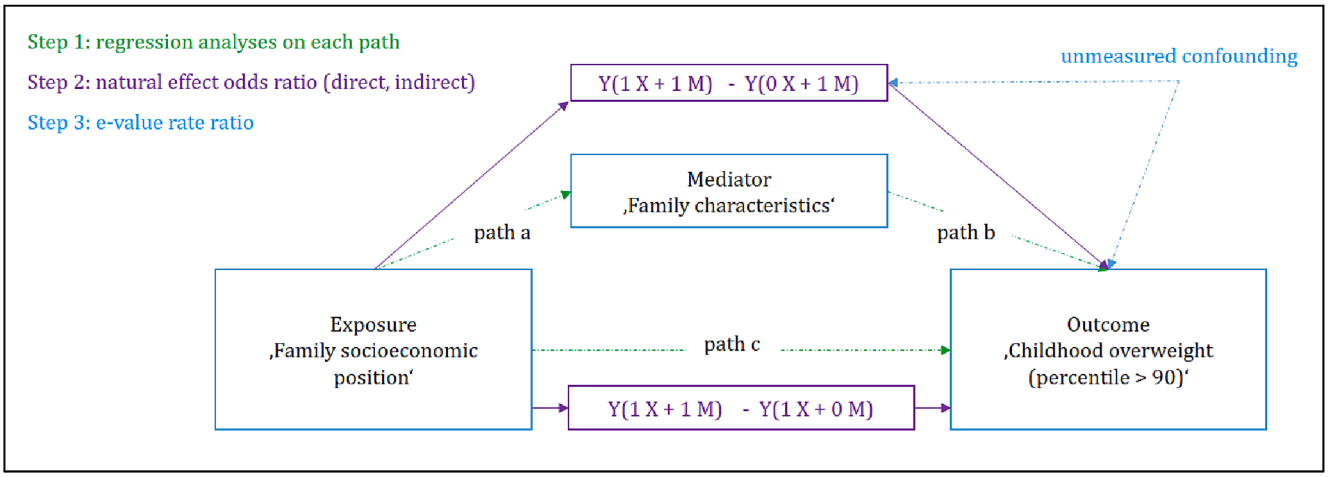

Fig. 1. Conceptual framework of the analytic strategy.

2.2. Variables

2.2.1. Dependent variable

Based on height and weight values measured in the primary study, we calculated sex- and age-specific percentiles ('bmi-for-age') according to German thresholds published by Kromeyer-Hauschild et al. (2001), the values of which have been considered valid for German children and adolescents (Rosario et al., 2010). Each child was assigned to overweight/obesity with a BMI percentile >90 (German Obesity Society, 2019; Schienkiewitz et al., 2019). The variable was dummy-coded [normal weight/overweight].

2.2.2. Exposure variables

According to the International Standard Classification of Education (ISCED, 2015), the primary caregivers' school education was assigned to be low (<10th grade) or high (≥10th grade). Their vocational education was dichotomized [no/any education]. In 2017, 11% of the German population lived in permanent poverty (German Federal Ministry of Labour and Social Affairs, 2021). Previous studies suggest that poverty experiences during childhood are associated with a risk of childhood overweight (Min et al., 2018). We defined family poverty by net income of <1,500/≥1,500 Euro.

2.2.3. Mediator variables

We selected family investment and family role model variables with focus on main determinants of overweight (i.e., nutrition, physical activity (Park et al., 2019)). We operationalized single indicators about whether the child eats sweets in front of the TV in a week [no/yes], the child consumes soft drinks in a week [no/yes], the family cooks irregularly [yes/no], the family and the child share time outdoor in a month [more often/seldom], the child does sports regularly in a club separately or jointly with the caregiver (e.g., 'mother–child gymnastics') in a month [yes/no], the biological mother was overweight or the biological father [no/yes], the family spend >30 min per day on screens in their free time [no/yes], and the number of times per week the child eats breakfast together with a caregiver [4–7/1-3times] or helps setting the table [≥1 time/<1 time].

2.2.4. Covariates

A migration status was assumed, if both biological mother and biological father were not born in Germany or if the child and at least one biological parent were not born in Germany (Schenk et al., 2006). We added this to a dichotomous variable [no migration history/migration history].

Supplement 1 lists all variables used.

2.3. Statistical methods

We compared baseline characteristics in family SEP using χ^2 test. We performed available-case analyses based on subsets of data that depend on missing data of family SEP, covariate variables and family characteristic variables. Although this method preserves information for each subset and can increase statistical power, the underlying data may limit the external validity of each subset (Salgado et al., 2016). Therefore, we discuss each subset used for single mediation analyses. For each subset, information on missing data was provided. All analyses were performed using R (version 4.0.3 2022) stratified by sex. Previous studies suggest sex differences in the overweight prevalence, as outlined above (Shah et al., 2020). Analyses include determinants that may differ for girls and boys, requiring stratified analyses by sex (Yang et al., 2019). Since we aimed to interpret our research questions based on correct results for boys and girls separately, we present stratified results and did not analyse effect modification by sex. All tests were considered to be statistically significant at p <.05.

Three-step approach in statistically modeling (Fig. 1).

(1) **In a first step,** we aimed to identify potential mediator variables of FC through which family SEP affects children's overweight. Based on the statistical considerations as recommended by Baron and Kenny (1986), SEP has to significantly predict (p <.05) the overweight (path c). In addition, potential mediator variables have to be associated with both SEP (path a) and the outcome (path b). Hence, we estimated three regression models on selected datasets of variables in two gender strata, while excluding cases with missing data in each variable used and while using the same set of covariates in each model (i.e., child age [in months], migration history). The Supplement 2 contains mathematical equations.

Based on the difference in the deviance statistics, we used ANOVA with chi-square to investigate whether the mediator-outcome model Yi better predicts the outcome variable and, thus, better fits the data compared to the path c model (Zi).

(2) **For step two**, we conducted *regression-based single mediation analyses* in order to decompose the total effect of SEP on children's overweight into a direct effect (unmediated) and an indirect effect (mediated) (Robins and Greenland, 1992; Smith and VanderWeele, 2019; Valeri and VanderWeele, 2013). The literature distinguishes between two types of natural (in)direct effects: a. the natural total (in) direct effect and b. the pure natural (in)direct effect, both of which we tested for equality. Since we aimed to test the hypotheses on social causation using the family investment model, we calculated both the pure natural indirect effect and the total natural indirect effect as suggested by Hafeman and Schwartz (2009). The results can be interpreted as to whether the association between family SEP and children's overweight is mediated (i.e., social causation) or confounded by family characteristics. We used the cmest() function in R (package CMAverse) (Shi et al., 2021; Valeri and VanderWeele, 2013). We presented the proportion of the total effect mediated by the mediator (VanderWeele and Vansteelandt, 2010). The used function (cmest()) allows to integrate any mediation model types and inferential tests by bootstrapping (i.e., confidence intervals and p-values) (Valeri and VanderWeele, 2013). The number of boots applied was set to default (200).

We found no evidence for significant multicollinearity with variance inflation factors (VIF) below 1.2 for all predictors (boys: sweets in front of TV, joint family sports activities) each with caregivers' highest primary education, child age and migration history. In each mediator-outcome model, the average VIF was < 1.1 (boys) and tolerance statistics were >0.86 (boys) (Menard, 2002; Myers, 1991).

(3) **In a third step**, we conducted sensitivity analyses (Cox et al., 2013; Forastiere et al., 2018). Supplement 5 contains the methods and results.

3. Results

Sample characteristics of n = 872 analyzed children (48.2 % female, 51.8 % male) are displayed in Table 1. Among girls, 5.7% were overweight, and among boys, the prevalence was 7.7%.

Only the caregivers' highest school education significantly predicted boys' and girls' overweight (p <.05).

For boys, 'sweet consumption in front of the TV' was associated with both caregivers' highest school education (OR = 3.92, path a) and overweight (OR = 2.70, path b). Among boys and girls, 'no child sports sparately or jointly family sports' was associated with caregivers' low education. Only in boys, this was also associated with overweight (Tables 2 and 3). No parental role model variables were associated with education and overweight (Table 4).

The association between education and overweight was mediated by 'sweets consumption in front of the TV' (OR = 1.31) to the extent of 43 %. In case of 'children's sports separately or jointly with a caregiver', the mediated pathway (OR = 1.14) contributed to the extent of 22 % to the association between education and overweight (Table 5).

Table 1
Sample characteristics (n = 872).

	Boys	Girls
% (N)	51.8 (452)	48.2 (420)
Covariate variables		
Age, mean in months (SD) N	57.5 (8.2) 452	58.3 (8.5) 420
Migration history Yes (N) / No (N)	18.7 (73) / 81.3 (316)	17.44 (64) / 82.6 (303)
Body mass index age-/sex-specific percentiles	**% (N)**	**% (N)**
Normal weight ≥ 10 – ≤ 90 / Overweight > 90	92.3 (417) / 7.7 (35)	94.3 (396) / 5.7 (24)
Family socioeconomic position		
Caregivers' school education < 10th /≥ 10th grade	29.7 (124) / 70.3 (293)	34.3 (134)/65.7 (257)
Caregivers' vocational education No / Yes	13.9 (56)/86.1 (347)	12.5 (47)/87.5 (329)
Income poverty Yes / No	10.6 (37)/89.4 (310)	12.4 (44)/87.6 (312)
Family investment in nutrition		
Child eats sweets in front of the TV Yes/No	52.4 (202)/47.5 (223)	58.6 (232) / 41.4 (164)
Child consumes softdrinks Yes/No	23.6 (89) / 76.4 (288)	26.3 (94) / 73.7 (264)
Breakfast together 1–3 /4–7 times per week	20.1 (81) / 79.9 (322)	21.9 (78)/ 79.0 (293)
Child helps setting table < 1 / ≥ 1 time per week	22.2 (94)/ 77.8 (331)	15.6 (62)/ 84.4 (335)
Family cooks meals No/Yes	12.2 (51) / 87.8 (369)	12.2 (48) / 87.8 (348)
Family investment in physical activity		
Shared time outdoor No-seldom / Yes–more often	69.3 (295) / 30.7 (131)	69.3 (278) / 30.7 (123)
Child sports separately or shared No / Yes	33.5 (141) / 66.5 (280)	32.3 (127) / 67.7 (267)
Family role models		
Overweight of biological mother or father Yes / No	66.2 (244) / 33.8 (125)	72.0 (248) / 28.0 (96)
Family watches TV > 30 Minutes per day Yes / No	81.2 (333) / 18.8 (77)	82.3 (323) / 17.2 (67)

Note: N = sample size; Supplement 4 includes details on missing data of each variable.

4. Discussion

Our study explored the association between family SEP and overweight among preschoolers and aimed to investigate the extent to which FC account for a socioeconomic gradient in overweight. The prevalence of overweight (bmi percentile > 90) was approximately 7.0%, which is in line to data of KiGGS in year 2018 (9.0%) (Schienkiewitz et al., 2019).

4.1. Research question 1

We found that low levels of caregivers' school education was significantly associated with higher odds of overweight. This is consistent with evidence demonstrating associations between low education and overweight in early childhood (Tester et al., 2018). By contrast, we found no evidence to suggest that poverty or vocational education were associated with increased odds in overweight. We were not able to replicate previous findings according to which low income is associated with increased prevalence (Bates et al., 2018). However, there are limitations to the comparability of these findings, as Bates et al. considered different age groups compared to our study (2–19 years).

4.2. Research question 2

Our findings suggest that caregivers' education predicts family investment in nutrition behavior and physical activity, some of which were associated with overweight. Recent findings are in line with findings on the influence of FC on overweight. For example, Park et al. (2019) identified practices for child feeding, child routines (i.e., screen time, sleep hours) associated with the weight of 2–5 year old children. Furthermore, Bates et al. (2018) found family routines and limited screen time to be relevant factors for childhood overweight.

4.3. Research question 3

For boys, family investment in nutrition and sports activity were associated with both education and overweight. The risk that an unmeasured confounder explained the association/indirect effect rather than the measured mediator was (considered to be) low (see sensitivity analyses in Supplement 5). We conclude that the educational gradient in boys' overweight is in part mediated by 'sweets consumption in front of the TV' and by 'child sports separately or jointly with a caregiver'.

Our results partially support the above FIM (Duleep, 1998) by emphasizing that low parental educational attainment affects the extent of parental investment in children (i.e., in nutrition, in physical / sports activity), resulting in higher odds of overweight among boys. Recent findings add to results for 11- to 17-year-old children showing that family nutrition and family screen time mediate the association between parental education and higher BMI (Seum et al., 2022). However, the mediation models used were based on a counterfactual framework published by Vanderweele and Vansteelandt (2009), in which we assumed unidirectional associations between family SEP, separate family characteristics and children's overweight. This assumption could be wrong for the following reasons. First, theoretically discussed associations between family SEP and health relate to social causation, which we examined here using the family investment model. However, studies also suggest that the opposite direction may also be true for childhood health (i.e., so-called social selection) (Conger and Donnellan, 2007). Second, the hypothesized effect between FC and childhood overweight could be interpreted inversely or bidirectionally. In context of child health inequalities this is assumed by an interactionist model describing a reciprocal relationship with parental characteristics (Conger and Donnellan, 2007). Paschall and Mastergeorge (2016) provide an overview about bidirectionality in parent–child relationships. Third, different associations could be possible if mediator variables are considered simultaneously. Hence, to evaluate unidirectional associations as well as multiple risk factors for childhood overweight is beyond our research question, further empirical research could consider i) multiple mediators, ii) bidirectional associations, and iii) different potential pathways underlying health inequalities (e.g., health selection).

We found that measured family investment in physical activity and in nutritional behavior to be relevant to boys' health inequalities. Our study suggests possible gender differences in the relevance of the family for educational gradients in overweight in early childhood. Recent studies on social contexts also provide gender-specific determinants in children's weight status (Shah et al., 2020). For example, Herr et al. (2022) found that boys' BMI may be associated with preschools' group composition. The authors argue that kindergartens could provide different resources for healthy behavior (e.g., physical activity) (Herr et al., 2022). Although we did not aim to test effect modification, gender differences in family influences on childhood overweight may be of interest for future research that considers, for instance, socialisation, health behaviour (Molnár and Livingstone, 2000), or gender-based

Table 2
Mediational regression analyses to identify potential *family investment in nutrition* as mediator variables in the association of caregivers' highest school education [high /low] and children's overweight [no/ yes].

Number of Modelseries	**Regression / exposure, outcome, mediator variables**		**Regression coefficients (n = sample size used)**	
1	***Child consumes sweets in front of TV***		***Boys (n = 379)***	***Girls (n = 359)***
Path C	Overweight:	Low education	OR = 2.21 (0.99–4.85) p =.049 Res.Dev = 204.82	OR = 4.56 (1.55–15.18) p =.008 Res.Dev = 116.84
Path A	Sweets at TV:	Low education	OR = 3.92 (2.36–6.66) p <.001	OR = 3.84 (2.30–6.59) p <.001
Path B	Overweight:	Low education Sweets at TV	OR = 1.70 (0.75–3.81) p =.200 OR = 2.70 (1.13–7.21) p =.032 Res.Dev = 199.74*	OR = 5.15 (1.65–18.14) p =.006 OR = 0.67 (0.21–2.25) p =.503 Res.Dev = 116.40
2	***Child consumes soft drinks***		***Boys (n = 334)***	***Girls (n = 330)***
Path C	Overweight:	Low education	OR = 2.32 (0.97–5.49) p =.055 Res.Dev = 173.81	OR = 4.68 (1.58–15.64) p =.007 Res.Dev = 113.94
Path A	Softdrinks:	Low education	OR = 2.52 (1.43–4.42) p =.001	OR = 2.33 (1.38–3.93) p =.002
Path B	Overweight:	Low education Softdrinks	OR = 2.17 (0.89–5.22) p =.083 OR = 1.46 (0.56–3.54) p =.420 Res.Dev = 173.18	OR = 4.62 (1.53–15.67) p =.008 OR = 1.08 (0.32–3.27) p =.892 Res.Dev = 113.92
3	***Family shared breakfast***		***Boys (n = 362)***	***Girls (n = 341)***
Path C	Overweight:	Low education	OR = 1.76 (0.72–4.14) p =.200 Res.Dev = 180.22	OR = 5.57 (1.73–21.34) p =.006 Res.Dev = 101.45
Path A	Breakfast:	Low education	OR = 1.63 (0.94–2.77) p =.076	OR = 2.25 (1.25–4.06) p =.007
Path B	Overweight:	Low education Shared breakfast	OR = 1.75 (0.71–4.11) p =.206 OR = 1.20 (0.41–3.02) p =.720 Res.Dev = 180.09	OR = 5.11 (1.56–19.81) p =.010 OR = 1.92 (0.50–6.74) p =.317 Res.Dev = 100.49
4	***Child helps setting table***		***Boys (n = 378)***	***Girls (n = 359)***
Path C	Overweight:	Low education	OR = 2.16 (0.97–4.73) p =.056 Res.Dev = 204.88	OR = 4.63 (1.57–15.41) p =.007 Res.Dev = 116.69
Path A	Setting table:	Low education	OR = 1.24 (0.71–2.14) p =.434	OR = 1.74 (0.95–3.16) p =.068
Path B	Overweight:	Low education Setting table	OR = 2.07 (0.93–4.55) p =.071 OR = 2.48 (1.10–5.46) p =.025 Res.Dev = 200.17*	OR = 4.59 (1.55–15.36) p =.008 OR = 1.10 (0.24–3.73) p =.892 Res.Dev = 116.67
5	***Family cooks meals***		***Boys (n = 373)***	***Girls (n = 358)***
Path C	Overweight:	Low education	OR = 2.38 (1.06–5.30) p =.034 Res.Dev = 197.72	OR = 4.17 (1.37–14.12) p =.014 Res.Dev = 111.55
Path A	Family cooking:	Low education	OR = 1.16 (0.44–1.74) p =.669	OR = 1.35 (0.67–2.65) p =.394
Path B	Overweight:	Low education Family cooking	OR = 2.38 (1.05–5.31) p =.034 OR = 1.83(0.28–2.27) p =.540 Res.Dev = 197.37	OR = 4.24 (1.40–14.39) p =.013 OR = 0.52 (0.03–2.78) p =.534 Res.Dev = 111.09

Note: All analyses are adjusted for child age and migration history; Table rows shaded in gray illustrate potential mediator variables; Supplement 4 includes details on missing data of each variable; OR = Odds Ratio with 95% confidence intervals in brackets and p-value; Res.Dev. = Residual Deviance, with lower values indicating that the model is better at predicting the value of the response variable.
* = significantly better fit than path c model p <.05.

stereotypes and cultural norms according to children's weight status (Matthiessen et al., 2014; Shah et al., 2020).

As the data used was collected in 2009, the results may reflect the social situation in Germany at that time, where the employment rate of mothers in Germany was lower compared to other EU Member States (e.g., Germany 44%, Spain 54%, Portugal 76%). In addition, the number of full-time external childcare facilities (e.g. kindergartens) was considered to be insufficient (Family Research Baden-Württemberg, 2008). Since 2009, the proportion of maternal employment increased (2009: 58%; 2018: 64%), with part-time employment still predominating (Barth et al., 2020). However, the family characteristics associated with poverty persisted and the risk of poverty exacerbated over the past decade (e.g., families with more than three children, single parent households). Although the material prosperity of the German federal state of Baden-Württemberg is considered high, 12.9% of children were still affected by poverty in 2009 and 14.6% in 2018 (German Parity Welfare Association, 2018; State statistical office Baden-Württemberg, 2012; Statistical offices, 2020). Future research should examine other European countries as well as contemporary German society with changing demographic composition of families, psychosocial and material family characteristics (Campbell, 2016; Schneider et al., 2021a; Schneider et al., 2021b)). This could take into account population growth and immigration over the last 10 years (German federal state of Baden-Württemberg, 2020).

5. Strength and limitations

This study explored the association of family SEP and overweight in early childhood considering family characteristics in Germany, which - to our knowledge - has not been done yet. The analyzed outcome is based on the measured body weight and height according to a predefined measurement protocol that represents a strength. Despite item nonresponse in FC (mediator variables) – and, thus, reduction of sample sizes - we could include subsamples with low levels of education in the statistical analyses (here about 30%). For example, the representative 'German Health Interview and Examination Survey for Children and Adolescents' (KiGGS for short) comprised only 7.7% low educated mothers (Meyrose et al., 2019).

Table 3
Mediational regression analyses to identify potential *family investment in physical activity* as mediator variables in the association of caregivers' highest school education [high /low] and children's overweight [no/ yes].

Number of Modelseries	**Regression / exposure, outcome, mediator variables**		**Regression coefficients (n = sample size used)**	
1	***Child sports or shared sports***		**Boys (n = 376)**	***Girls (n = 358)***
Path C	Overweight:	Low education	OR = 2.45 (1.09–5.45) p =.027 Res.Dev = 198.85	OR = 4.70 (1.60–15.66) p =.007 Res.Dev = 116.37
Path A	Sports:	Low education	OR = 2.02 (1.23–3.30) p =.005	OR = 2.01 (1.19–3.39) p =.008
Path B	Overweight:	Low education	OR = 2.19 (0.97–4.92) p =.056	OR = 4.52 (1.52–15.19) p =.009
		Sports	OR = 2.24 (0.98–5.14) p =.053 Res.Dev = 195.16~	OR = 1.32 (0.39–4.19) p =.642 Res.Dev = 116.16
2	***Family shared time outdoor***		***Boys (n = 380)***	***Girls (n = 362)***
Path C	Overweight:	Low education	OR = 2.18 (0.98–4.78) p =.052 Res.Dev = 205.11	OR = 4.58 (1.55–15.26) p =.008 Res.Dev = 117.09
Path A	Time outdoor:	Low education	OR = 1.71 (1.02–2.92) p =.046	OR = 1.39 (0.84–2.33) p =.206
Path B	Overweight:	Low education	OR = 2.19 (0.98–4.83) p =.052	OR = 4.68 (1.58–15.70) p =.007
		Time outdoor [no/seldom]	OR = 0.95 (0.42–2.26) p =.894 Res.Dev = 205.10	OR = 0.76 (0.25–2.55) p =.633 Res.Dev = 116.86

Note: All analyses are adjusted for child age and migration history; Table rows shaded in gray illustrate potential mediator variables; DV = dependent variable; Supplement 4 includes details on missing data of each variable; OR = Odds Ratio with 95% confidence intervals in brackets and p-value; Res.Dev. = Residual Deviance, with lower values indicating that the model is better at predicting the value of the response variable.
~ = better fit than path c model marginal significant at p <.1.

The analysis has several limitations. First, the geographic region of the present data refers to kindergarten sites from southern Germany (De Bock et al., 2010). By this account, information on the prevalence of overweight and family characteristics depend in part on the recruitment strategy used in the original study population. Hence, further research could expand the sample by considering other geographic regions to confirm the robustness of the current findings. To extend on the research questions discussed in our paper, it would be worthwhile to conduct further analyses of associations with kindergarten characteristics, some of which have been done with multilevel approaches in previous studies on the same data used. For example, Herr et al. (2022) found that the group size of kindergartens is associated with SDS BMI. Second, current analyses are based on family characteristics and health outcomes examined cross-sectionally. Therefore, temporal trends/causal explanations in health behaviors or in overweight could not be considered. Further work could adapt longitudinal research perspectives on health behaviors (e.g., learning theories of "short-term benefits versus long-term harms" (Sallis, 2010)) on theories of family investment. Third, BMI age- and sex-specific percentiles were used in the present study to operationalize overweight. Nationally and internationally, age- and sex-specific BMI percentiles are commonly used to measure overweight among children. Validated velocity standards could be applied by further research efforts to evaluate a changing growth rate in early childhood (World Health Organization, 2009). Fourth, the family characteristic variables were observed in the primary study in year 2009 according to nutrition and physical activity as determinants of overweight. Fifth, small observation numbers (e.g., in the dependent variable or in risk factors) may induce the following problems. For example, binary logistic regression models may not converge (Heinze and Schemper, 2002). However, this was not the case in our study. The analysis of binary dependent variables with few events could also lead to misestimation of the regression coefficient (King and Zeng, 2001; Woo et al., 2022) and missing detection of associations. As the prevalence of overweight is comparable to large national surveys, we suggest the risk

Table 4
Mediational regression analyses to identify potential *family role models* as mediator variables in the association of caregivers' highest school education [high /low] and children's overweight [no/ yes].

Number of Modelseries	**Regression / exposure, outcome, mediator variables**		**Regression coefficients (n = sample size used)**	
1	***Parental overweight***		***Boys (n = 347)***	***Girls (n = 325)***
Path C	Overweight:	Low education	OR = 2.06 (0.90–4.64) p =.082 Res.Dev = 190.03	OR = 6.08 (1.67–28.76) p =.010 Res.Dev = 87.68
Path A	Parental overweight:	Low education	OR = 1.75 (1.04–3.01) p =.039	OR = 1.97 (1.13–3.55) p =.019
Path B	Overweight:	Low education	OR = 1.84 (0.80–4.17) p =.143	OR = 5.81 (1.58–27.72) p =.013
		Parental overweight	OR = 4.31 (1.46–18.46) p =.019 Res.Dev = 182.49*	OR = 1.46 (0.35–9.92) p =.639 Res.Dev = 87.45
2	**Family TV time**		**Boys (n = 364)**	**Girls (n = 353)**
Path C	Overweight:	Low education	OR = 2.34 (1.01–5.31) p =.042 Res.Dev = 188.26	OR = 4.24 (1.40–14.30) p =.013 Res.Dev = 110.89
Path A	Family TV:	Low education	OR = 1.39 (0.76–2.65) p =.303	OR = 1.32 (0.72–2.51) p =.382
Path B	Overweight:	Low education	OR = 2.31 (1.00–5.24) p =.045	OR = 4.71 (1.53–16.18) p =.008
		Family TV	OR = 1.35 (0.49–4.76) p =.592 Res.Dev = 187.96	OR = 0.23 (0.08-0.76) p =.012 Res.Dev = 105.16*

Note: All analyses are adjusted by child age and migration history; DV = dependent variable; Supplement 4 includes details on missing data of each variable; OR = Odds Ratio with 95% confidence intervals in brackets and p-value; Res.Dev. = Residual Deviance with lower the value, the better the model is able to predict the value of the response variable.
* = significantly better fit than path c model p <.05.

Table 5
Indirect effect of 'sweets consumption in front' of the TV and 'child sports separately or jointly with a caregiver' highest school education [high /low] and boys' overweight [no/ yes].

	Single mediation analysis[1]	Single mediation analysis[1]
	Mediator: sweets in front of TV	**Mediator: child sports / family shared sports**
Pure indirect effect [2]	OR = 1.31 (1.05–1.59)	OR = 1.14 (1.01–1.38)
Total indirect effect[2]	OR = 1.31 (1.05–1.59)	OR = 1.14 (1.01–1.38)
% mediated	42.93	21.29
	Additional model information	**Additional model information**
Sample size N	379	376
Caregivers' school graduation *< 10th grade;* % (N)	29.3 (111)	29.5 (111)
Migration historyYes; % (N)	17.9 (68)	17.8 (67)
Overweight % (N)	7.9 (30)	7.7 (29)

Note: OR = Odds ratio with bootstrap confidence intervals in brackets (number of boots 200 (default)).
[1] No interaction term between family SEP and family characteristic variable included as it was no statistically significant.
[2] Pure indirect effect and total indirect effect are equal and non-zero, indicating both, that there is no statistical interaction between mediator and family SEP and that family SEP causes the mediator to affect the dependent variable (i.e. there is no confounding by mediator) (Hafeman and Schwartz, 2009; VanderWeele, 2014).

of bias to be low, although this should be investigated by further research.

6. Conclusion

The present study found an association between caregivers' school education and overweight in early childhood. Additionally, our study discovered educational gradients in family characteristics that, in turn, contributed to overweight among preschool boys, but not among girls. Therefore, gender-specific research might be of interest to identify family risk and protective characteristics that explain health inequalities in boys and girls.

Ethical approval

As no primary data were analysed for this study an ethical approval was not required. For the original study, an ethical approval was granted by the Ethics committee of the Medical Faculty Mannheim, Heidelberg University (ID 2008-275N-MA).

CRediT authorship contribution statement

Stephanie Hoffmann: Methodology, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Lydia Sander:** Writing – review & editing. **Petra Rattay:** Writing – review & editing. **Miriam Blume:** Writing – review & editing. **Claudia Hövener:** Writing – review & editing. **Sven Schneider:** Writing – review & editing. **Matthias Richter:** Writing – review & editing. **Claudia R. Pischke:** Writing – review & editing. **Wiebke Schüttig:** Writing – review & editing. **Freia De Bock:** Methodology, Writing – review & editing. **Jacob Spallek:** Conceptualization, Methodology, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary material

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