SOCIAL INEQUALITIES IN CHILDREN'S LIFESTYLE BEHAVIORS AND HEALTH OUTCOMES

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Social Inequalities in Children's Lifestyle Behaviors and Health Outcomes

Sociale ongelijkheden in leefstijlgedragingen en gezondheidsuitkomsten van kinderen

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Copromotor	Dr. A. van Grieken

CONTENTS

MANUSCRIPTS THAT FORM THE BASIS OF THIS THESIS

Chapter 2

Junwen Yang-Huang, Amy van Grieken, Lu Wang, Wilma Jansen, Hein Raat. Clustering of sedentary behaviours, physical activity, and energy-dense food intake in six-year-old children: associations with family socioeconomic status. *Nutrients 2020;12(6):1722. (IF=4.546; top 25%)*

Chapter 3

Junwen Yang-Huang, Amy van Grieken, Henriëtte A. Moll, Vincent W.V. Jaddoe, Anne I. Wijtzes, Hein Raat. Socioeconomic differences in children's television viewing trajectories: a population-based prospective cohort study. *PLoS One 2017;12(12):e0188363. (IF=2.766; top 25%)*

Chapter 4

Junwen Yang-Huang, Amy van Grieken, Lu Wang, Vincent W.V. Jaddoe, Wilma Jansen, Hein Raat. Ethnic background and children's television viewing trajectories: the Generation R Study. *PLoS One 2018;13(12):e0209375. (IF=2.776; top 50%)*

Chapter 5

Junwen Yang-Huang, Amy van Grieken, Evelien R. van Meel, Huan He, Johan C. de Jongste, Liesbeth Duijts, Hein Raat. Sociodemographic factors, current asthma and lung function in an urban child population. *European Journal of Clinical Investigation 2020:e13277. Doi:10.1111/eci.13277 (IF=3.481; top 25%)*

Chapter 6

Junwen Yang-Huang, Amy van Grieken, Yueyue You, Vincent W.V. Jaddoe, Eric A Steegers, Liesbeth Duijts, Mirte Boelens, Wilma Jansen, Hein Raat. Family poverty dynamics and child health at age 6 years: the Generation R Study. *Submitted for publication.*

Chapter 7

Lizi Lin, Junwen Yang-Huang, Haijun Wang, Susana Santos, Amy van Grieken, Hein Raat. Social mobility by parent education and childhood overweight and obesity at age 6 and 10 years. *Submitted for publication.*

CHAPTER 1

General introduction

Socioeconomic status

Socioeconomic status (SES) has a profound influence on health. Persons with a lower SES have higher rates of morbidity and mortality in asthma, cardiovascular disease, and cancer compared with persons having a higher SES [1-5]. Socioeconomic status is the social standing or position of an individual or group, which is often measured as a combination of education, income and occupation [6]. In this thesis, indicators of SES including educational level, household income, unemployment, and financial status are studied to represent the social position of an individual or family.

Inequalities in health studied in this thesis refer to differen ces in the health of individuals according to different indicators of SES [7]. Over the last decades, numerous studies have indicated inequalities in many different health outcomes between people with a high and low SES, such as cardiovascular disease [4], chronic disease [8], cancer [5], and general life expectancy [9]. Many of these social inequalities emerge in early life. Children from families with a lower SES have poorer physical and mental health outcomes compared to children from families with a higher SES [10-13]. In the Netherlands, for instance, higher rates of obesity [14], asthma [15], and behavioral problems [16] among children from families with a lower SES have been reported.

Furthermore, numerous studies have documented inequalities in the prevalence of preterm birth [17], chronic physical conditions [18], and socioemotional difficulties [19] among children with different ethnic backgrounds living in the same country. In the Netherlands, studies showed that children with an ethnic minority background (i.e. Turkish, Moroccan and Surinamese background) have an increased risk of overweight/obesity [20] and asthma [21] compared to children with a Dutch background.

Social inequalities in children's lifestyle behaviors and health outcomes

In a lifespan perspective, identifying social inequalities in children's lifestyle behaviors and health outcomes is critical for improving children's health, and to be able to initiate early interventions. In this thesis, three health outcomes related to social inequalities are studied: overweight/obesity, asthma, and health-related quality of life (HRQoL).

Childhood overweight and obesity

In developed countries, unhealthy lifestyle behaviors and subsequently having overweight and obesity, are major public health challenges, especially for children from families with lower SES [13, 14, 22-24]. Over the past decades, the prevalence of childhood overweight and obesity has increased notably [25]. Across European countries, data on the prevalence of overweight and obesity among 6- to 9-year-old school children was collected between 2007 and 2013. A quarter of children was classified as having overweight or obesity in 2007, increasing to a third of the children in 2013 [26, 27]. In the Netherlands, nationwide growth studies have shown that the prevalence of overweight and obesity among children aged 0-21 years has increased from 6% in 1980 to 14% in 2009 for boys, and from 7% to 15% for girls [20].

The primary causes of overweight and obesity in children can be traced to various lifestyle behaviors related to an energy imbalance between caloric intake and energy expenditure [23]. Based on existing literature, the lifestyle behaviors most consistently related to being at risk for childhood overweight and obesity include a high level of sedentary behavior (i.e. watching television and playing computer), lack of physical activity, and consumption of sugar-sweetened beverages [28-31]. Studies have shown that unhealthy lifestyle behaviors are more common among children from families with low SES [32-34]. However little is known about how social inequalities in these lifestyle behaviors evolve longitudinally [35-37]. Also, lifestyle behaviors have shown to cluster [38-42] and a particular combination of energy balance-related behavior night be more likely to be associated with the development of childhood overweight and obesity [43]. However, research on social inequalities in the clustering of energy-related lifestyle behaviors is scarce [39, 44, 45].

Asthma

Asthma is one of the most common chronic conditions in childhood [46]. Between 2000-2003, among 13-14-year old children, the prevalence rate of children ever having asthma was 13.8% globally and 16.3% in western Europe [46]. Various clinical and public health interventions focus on prevention and treatment of asthma symptoms in children, because asthma is related to school absenteeism, psychosocial problems, life-threatening exacerbations, and considerable morbidity [47, 48]. Asthma is a heterogeneous condition, characterized by chronic airway inflammation. It is defined by the history of respiratory symptoms such as wheeze, shortness of breath, chest tightness, and cough that vary over time and in intensity, together with variable expiratory airflow limitation [49]. Wheezing and shortness of breath are common asthma-like symptoms in early childhood [50]. Approximately 40% of all children worldwide have at least one episode of asthma-like symptoms in the first year of life [51], but it has been shown that only 30% of preschoolers with recurrent wheezing develop asthma at the age of 6 years [52]. Most of the wheezing symptoms are transient and do not develop into asthma later in life [52].

Furthermore, measurements of children's lung function provide information on lung development and the presence of asthma. Reliable information on lung volume and forced expiratory volume may benefit clinical assessment and follow-up treatment [53, 54]. Previous studies suggested that children from families with low SES and with an ethnic minority background are at higher risk for asthma [55-57]. However, findings of this association among children aged 9 and older are inconsistent [11]. Thus far only few studies have been performed on the associations between family SES and lung function among children [58, 59].

Health related quality of life

Health-related quality of life (HRQoL) is the component of overall quality of life that is modified by impairments, functional states, perceptions, and opportunities [60]. The measurement of HRQoL can be added to traditional health outcome measures as a subjective perception of physical and mental health [61]. Both overweight and asthma may be associated with reduced HRQoL [62-65]. A growing body of evidence shows that children with overweight or obesity may have a lower HRQoL than those with a healthy weight [62, 66, 67]. Furthermore, childhood asthma may be associated with a lower HRQoL, even when treatment is applied [64, 68]. Studies that investigate the associations between the indicators of SES and HRQoL may provide a broader view of social inequalities in health rather than a single health outcome.

The change in socioeconomic status and child health outcomes

The level of socioeconomic status of a family may change over time. A change can be caused by developments in various aspects, e.g. educational level, occupation, and household income. The impact of changes in the level of SES has been studied with regard to a wide range of health outcomes among adults. Individuals with a "static-low" SES across the life course have been reported to have a higher risk of overweight/obesity [69], cardiovascular disease [70], and a higher mortality rate [71] compared to those who experienced upward change in SES or had "stable high" SES. However, only few studies thus far assessed the associations between a change in SES and child health outcomes [72-74]. In this thesis, the associations between mobility in parental educational level and change in family income (i.e. dynamics of poverty status) with child weight status, asthma, and HRQoL were assessed. The presence of poverty was defined based on the equivalised household income being less than 60% of the median national income [75, 76]. In previous literature, the impact of poverty status changes on children's health has mainly been studied in relation to cognitive development and school achievement [74, 77]. Thus far research has not focused on the association of poverty status change and indicators of child health (e.g. weight status, chronic conditions). Studying the change in the SES and its associations with child health outcomes may contribute to understanding the pathways of social inequalities in child health.

Research questions

The main aim of this thesis was to study social inequalities in children's lifestyle behaviors and child overweight, asthma, and HRQoL. A conceptual framework is presented in figure 1. The framework was based on the social-ecological model [78]. The social-ecological model considers the impact of SES on the development of children's lifestyle behaviors, which in turn affect child health outcomes [78]. The following research questions were formulated:

Part one: Social inequalities in children's lifestyle behaviors

- Do clusters of energy-related lifestyle behaviors exist among children aged 6 years, and are the indicators of SES associated with the clusters of energy-related lifestyle behaviors?
- To what extent do social inequalities in child TV viewing time exist, and how do these inequalities change from child age 2 years to 9 years?
- To what extent do inequalities in child TV viewing time exist related to ethnic background, and how do these inequalities change from child age 2 years to 9 years?

Part two: Social inequalities in child health outcomes

- Are indicators of family SES and child ethnic background associated with childhood asthma and lung function in children aged 10 years?

Part three: Associations between the change in socioeconomic status over time and child health outcomes

- To what extent are the timing and the presence of family poverty from pregnancy to child age 6 years associated with child overweight, asthma, and HRQoL?
- To what extent is a change in parental educational level from pregnancy to child age 6 years associated with child weight status at child age 6 and 10 years?

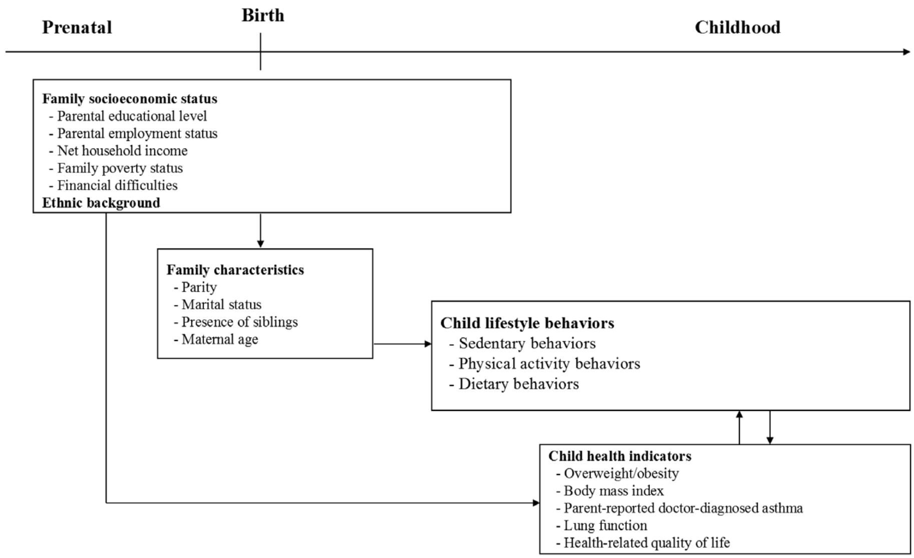

Figure 1. Conceptual Framework of associations between indicators of socioeconomic status and ethnic background with children's lifestyle behaviors and indicators of health. Framework is based on the social-ecological model [78].

Methods

The studies conducted in this thesis were embedded in the Generation R Study. The Generation R Study is a population-based prospective cohort study from fetal life until adulthood in Rotterdam, the Netherlands. The study is designed to identify early environmental and genetic determinants of normal and abnormal growth, development, and health [79]. Midwives and obstetricians invited all pregnant women under their care with an expected delivery date between April 2002 and January 2006. In total, the cohort included 9,778 mothers and their children living in the study area. While enrollment was aimed at early pregnancy, it was possible to enroll until the birth of the child. Assessments during pregnancy were planned in early pregnancy (gestational age <18 weeks), mid-pregnancy (gestational age 18-25 weeks), and late pregnancy (gestational age ≥ 25 weeks), and included physical examinations, ultrasound assessments, and self-administered questionnaires. Data collection for the children in the preschool period, from birth to 4 years of age, was performed by a home-visit at the age of 3 months, and by questionnaires and routine child health center visits [80]. Data collection in the school-aged period, age 5 years and onwards, included parent-reported questionnaires and regular detailed hands-on assessments performed with all children in a dedicated research center [81].

Outline of this thesis

The research questions of this thesis are addressed in several studies presented in the following chapters. Part one is devoted to social inequalities in children's lifestyle behaviors. Chapter 2 focuses on social inequalities in the clustering of energy balance-related lifestyle behaviors. Chapter 3 and 4 describe the social inequalities in repeatedly-measured child television viewing time. Part two relates to social inequalities in child health outcomes. Chapter 5 presents the social inequalities in asthma and lung function. Part three presents studies on the associations between the change in family SES and child health outcomes. Chapter 6 describes the associations between family poverty dynamics and child weight status, asthma, and HRQoL. Chapter 7 focuses on the associations between the change in parental educational level and child weight status at later ages. Chapter 8 provides an overall discussion of the main findings. An overview of the studies described in this thesis is shown in table 1.

Table 1. Overview of studies presented in this thesis

Chapter	Study design	Age (years)	N	Main exposures	Main outcomes
Social inequalities in children's lifestyle behaviors					
2	Cross-sectional	6	4,059	Maternal educational level, net household income	Clusters of energy-related lifestyle behaviors (total screen time, physical activity, calorie-rich snack consumption, sugar-sweetened beverages consumption)
3	Longitudinal*	2-9	3,561	Maternal educational level, net household income	TV viewing time
4	Longitudinal*	2-9	4,833	Ethnic background	TV viewing time
Social inequalities in child health outcomes					
5	Cross-sectional	10	5,237	Multiple SES indicators, ethnic background	Current asthma, lung function
Associations between the change in socioeconomic status over time and child health outcomes					
6	Longitudinal†	6	3,968	Family poverty status	Overweight/obesity, asthma, health-related quality of life
7	Longitudinal‡	6 and 10	4,030	Change in parental educational level	Overweight/obesity, BMI SDS

SES = socioeconomic status. BMI = body mass index. SDS = standard deviation score.
* Repeatedly measured outcome.
† Repeatedly measured exposure.
‡ Repeatedly measured exposure and outcome.

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1 Social inequalities in children's lifestyle behaviors

CHAPTER 2

Clustering of sedentary behaviours, physical activity, and energy-dense food intake in six-year-old children: associations with family socioeconomic status

Junwen Yang-Huang, Amy van Grieken, Lu Wang, Wilma Jansen, Hein Raat

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Abstract

This study examined the clustering of lifestyle behaviours in children aged six years from a prospective cohort study in the Netherlands. Additionally, we analysed the associations between socioeconomic status and the lifestyle behaviour clusters that we identified. Data of 4059 children from the Generation R Study were analysed. Socioeconomic status was measured by maternal educational level and net household income. Lifestyle behaviours including screen time, physical activity, calorie-rich snack consumption and sugar-sweetened beverages consumption were measured via a parental questionnaire. Hierarchical and non-hierarchical cluster analyses were applied. The associations between socioeconomic status and lifestyle behaviour clusters were assessed using logistic regression models. Three lifestyle clusters were identified: "relatively healthy lifestyle" cluster (n = 1444), "high screen time and physically inactive" cluster (n = 1217), and "physically active, high snacks and sugary drinks" cluster (n = 1398). Children from high educated mothers or high-income households were more likely to be allocated to the "relatively healthy lifestyle" cluster, while children from low educated mothers or from low-income households were more likely to be allocated in the "high screen time and physically inactive" cluster. Intervention development and prevention strategies may use this information to further target programs promoting healthy behaviours of children and their families.

Introduction

Childhood obesity is a major public health problem in most developed and developing countries [1]. In 2014, the average percentage of overweight and obese children was 19% in Europe [2]. The primary causes of overweight and obesity in children can be traced to various lifestyle behaviours related to imbalance between calorie intake and energy expenditure [1].

Research on co-occurrence or clustering of energy-related lifestyle behaviours, such as dietary behaviours, sedentary behaviours, and physical activity in children has increased [3-7]. It has been shown that healthy and unhealthy behaviours co-occur in children in complex ways [8]. Evaluating the synergetic effect instead of the isolated effects of lifestyle behaviours will help intervention development to further target lifestyle behaviours simultaneously [9]. Furthermore, studies have shown that socioeconomic status (SES) is associated with certain lifestyle behaviour clusters [10-13]. For example, Leech et al. found that a higher proportion of children aged 10–12 years with mothers having low educational level tended to be in the "energy dense food/drink consumers who watch TV" cluster [10]. Ottevaere et al. reported that adolescents aged 12.5–17.5 years with higher educated parents were more likely to be in the "healthy" cluster and the "healthy eating, low physical activity and low sedentary behaviour" cluster [13]. Research on the associations between SES and lifestyle behaviour clusters may be helpful to identify subgroups at increased risk in developing overweight and obesity.

A systematic review pointed out that few studies have examined the clustering of lifestyle behaviours among children younger than nine [4, 7, 14, 15]. Identifying the clustering of lifestyle behaviours in school-aged children is important, since screen behaviour, physical activity, and dietary behaviours are established in early childhood and can be tracked into later life [16, 17]. Among school-aged children, besides their own preferences, parents play an important role in the development of children's lifestyle behaviours through their parental attitudes, parenting practices, financial capabilities, and personal lifestyle behaviours. In the studies focusing on socioeconomic inequalities in clustering of lifestyle behaviours, parental educational level was the most common measure of SES [4]. Other indicators of SES have been researched sparsely [18, 19]. Studying a variety of SES indicators may provide a complete overview of the impact of socioeconomic status on the clustering of child lifestyle behaviours [20].

This study firstly examined the co-occurring patterns of lifestyle behaviours, including screen time, physical activity, calorie-rich snack consumption, and sugar-sweetened beverages consumption, in children aged six years from a prospective cohort study in the Netherlands. Secondly, we analysed the associations between SES, measured by both maternal educational level and net household income, and the lifestyle behaviour patterns that we identified.

Materials and Methods

Study Design

The study was embedded in the Generation R Study. The Generation R Study is a prospective population-based birth cohort in Rotterdam, The Netherlands. The cohort includes 9778 mothers and their children who were born between 1 April 2002 and 31 January 2006 [21]. Consent for follow-up was available for 8305 children at aged 6 years. Children with information on lifestyle behaviours (i.e., screen time, physical activity, calorie-rich snack, and sugar-sweetened beverages) available were included in the study (n = 4516). In total, 12 children did not have data on maternal educational level and net household income; these cases were excluded. Second (n = 293) and third children (n = 6) of the same mother were excluded for analyses to avoid clustering. Univariate outliers (i.e., screen time > 6 h/day, physical activity > 6 h/day, calorie-rich snack > 4 portion/day, sugar-sweetened beverages > 7 portion/day) were removed, leaving a study population of 4059 participants. The study was approved by the Medical Ethics Committee of the Erasmus University Medical Centre (MEC 217.595/2002/202). Written informed consent was obtained from all participants.

Socioeconomic Status

Maternal educational level was obtained via questionnaire when the child was 6 years old using the Dutch Standard Classification of Education. Four education levels were categorized: low (no education, primary school, lower vocational training, intermediate general school, or four years or less general secondary school), mid-low (more than four years general secondary school, intermediate vocational training, or first year of higher vocational training), mid-high (higher vocational training), and high (university or PhD degree) [22]. Net household income was obtained by questionnaire when the child was 6 years old and categorized as low (<€2000/month), middle (€2000–€3200/month), or high (>€3200/month).

Lifestyle Behaviours

Children's lifestyle behaviours, including total screen time, physical activity, calorie-rich snack, and sugar-sweetened beverages, were measured using a parental questionnaire when the child was age 6.

Screen Time

Parents reported children's time spent on television viewing and computer playing respectively. For television viewing time, parents were asked to report the average number of days per week (0–5 days) and per weekend (0–2 days) their child spent watching television, videos, or DVDs. On the days that their child spent watching television, videos or DVDs, parents reported the average number of hours in the morning, afternoon, and evening after dinner per weekday/weekend day. The average time children spent on television viewing per day was calculated by the following formula: [weekdays ×

(hours in the morning + hours in the afternoon + hours in the evening after dinner) + weekend days × (hours in the morning + hours in the afternoon + hours in the evening after dinner)]/7. The same set of questions was used to assess children's time spent behind a computer, which included game computers such as a PlayStation, Gameboy and Nintendo. The average computer time per day of the child was calculated according to the same formula as for television time. Total screen time per day was calculated by adding up children's television time and computer time.

Physical Activity

Parents reported children's sports participation and outdoor play respectively. For sports participation, parents were asked to name the sport that their children took part in. Frequency (i.e., number of times per week) and duration (i.e., average hours for each training session or match) were reported. Response categories for frequency ranged from '1 time per week' to 'more than 3 times per week'. Response categories for duration included: 'less than 30 min', '30 to 60 min', and 'more than 1 hour'. The average time the child spent on sport per day was calculated using the following formula: times per week * average hours each session/7. School physical educational lessons and swimming lessons were assessed separately and were not included in the assessment of sports participation.

Parents reported the frequency (i.e., number of days) and duration (i.e., average hours in the morning, afternoon, or evening after dinner) of children's outdoor play for weekdays and weekend days separately. Response categories for duration included: 'never', 'less than 30 min', '30–60 min', '1–2 h', '2–3 h', and '3–4 h'. The average outdoor play time per day was calculated using the following formula: [weekdays × (hours in the morning + hours in the afternoon + hours in the evening after dinner) + weekend days × (hours in the morning + hours in the afternoon + hours in the evening after dinner)]/7. Physical activity time per day was calculated by adding up children's sports participation and outdoor play.

Calorie-Rich Snack

Consumption of calorie-rich snacks was assessed by the following question for weekdays and weekend days separately: How often, on average, does your child eat a calorie-rich snack? The following definition was provided to parents: a calorie-rich snack is something that is eaten between the three main meals, such as chips, nuts, chocolate bars, cookies, or ice cream. Response categories for this question included: 'never or less than once per day', 'once per day', '2–3 times per day', '4–6 times per day', and '7 or more times per day'. The middle number of portions of each category (e.g., 5 portions for 4–6 times per day) was used to estimate the average consumption of calorie-rich snacks. The number of snacks on weekdays and weekend days was summed up and then divided by seven days to calculate the average total calorie-rich snack consumption per day.

Sugar-Sweetened Beverages

Consumption of sugar-sweetened beverages was assessed using the following question for weekdays and weekend days separately: On average, how many glasses/packages of sugar-sweetened beverages does your child drink? Parents received the following definition of sugar-sweetened beverages: sugar-sweetened beverages are those beverages containing a great deal of (added) sugar, including soft drinks, fruit juices, lemonade, and sweetened milk products (e.g., chocolate milk). Response categories ranged from 'none or less than 1' to '7 or more' (8 categories in total). The number of sugar-sweetened beverages on weekdays and weekend days were summed and then divided by seven days to calculate the average total sweet beverage consumption per day.

Potential Confounders

Based on the literature, several characteristics were considered potential confounders in the analyses: child sex (boy/girl), age (years), ethnic background, and child weight status [4, 23]. Information on child ethnic background (western, non-western) was based on the parents' country of birth, which was obtained by questionnaire when the child was 6 years old. If one of the parents was born outside the Netherlands, this country of birth determined the ethnic background of the child. If both parents were born outside the Netherlands, the country of birth of the mother determined the ethnic background of the child [24]. Height and weight were measured in lightweight clothes and without shoes, at the Generation R research center in the Erasmus Medical Center, Sophia's Children's Hospital. Body mass index (BMI) was calculated using the formula: weight (kilograms) divided by height (meters) squared. Children were categorized into overweight (including obesity) and normal weight according to international age- and sex-specific BMI cut-off points [25].

Statistical Analyses

To identify clusters of children with similar lifestyle co-occurring patterns, a combination of hierarchical and non-hierarchical cluster analyses were used [23]. Log transformation was applied to the four lifestyle behaviour variables because of positive skewedness. Z-scores of the log-transformed variables were calculated to standardize the variables before cluster analysis. First, a hierarchical cluster analysis was applied using Ward's method based on Euclidean distance [26]. At this stage, several possible cluster solutions with the number of clusters ranged from 3 to 6 were generated. Second, a non-hierarchical k-means cluster analysis was performed using the initial cluster centres generated from the hierarchical cluster analysis. Third, to test the stability of the generated cluster solutions, 50% of the study population was randomly selected and the clustering procedure was repeated. The agreement of the cluster assignment between the main study population and the randomly selected sample was assessed with Cohen's kappa (κ) [27].

Chi-square tests were performed to investigate the differences with regard to the cluster distribution by child characteristics and family SES. In each cluster, odds ratios for different SES indicators (high maternal educational level and high net household income as reference group) were calculated using logistic regression. Potential confounders (child sex, age, ethnic background, and child weight status) were included into the models. Bonferroni correction was applied for multiple testing [$p = 0.05/(\text{cluster number} \times \text{number of SES indicators})$]. Interaction effects between child sex and SES indicators were assessed in the logistic regression models. No statistically significant interaction effects were found ($p < 0.05$). Multiple imputation procedures were performed to impute missing data in the determinants and confounders (ranging from 0% to 9.3%, Table 1) using a fully conditional specified model. Five imputed datasets were generated, taking into account all the variables included in this study. Pooled estimates were used to report odds ratios (ORs) and their 95% confidence intervals (CIs). Statistical analyses were performed using IBM SPSS Statistics for Windows, version 24.0. Armonk, NY, USA: IBM Corp.

Non-Response Analyses

Children with missing data on at least one life style behaviour ($n = 3789$) were compared with children without missing data ($n = 4516$) using Chi-square tests. Data were more often missing for children from mothers with a low educational level, a low household income, or from non-western ethnic background (all $p < 0.05$). No statistically significant differences were found between boys and girls ($p = 0.64$).

Results

Table 1 shows the characteristics of children and their mothers. The mean age of the children was 6.0 (SD 0.4) years. Approximately 30% of the mothers had a high educational level. More than half of children (54.2%) lived in a high income household. Around three quarters (74.9%) of the children had a western ethnic background.

Description of the Clusters

Based on the four lifestyle behaviours, cluster analyses turned out a three-cluster solution (k agreement = 0.964) as the most adequate and stable representation. Figure 1 presents the three clusters derived from the cluster analysis. Cluster 1 was labelled “relatively healthy lifestyle”, and it was characterized by z-scores < 0 for total screen time, calorie-rich snack and sugar-sweetened beverages consumption, and relatively high in physical activity level (z-score = 0.21). Cluster 2 was labelled “high screen time and physically inactive”, and it was characterized by high total screen time level (z-score = 0.33) and low physical activity level (z-score = −0.90). Cluster 3 was labelled “physically active, high snacks and sugar-sweetened beverages”, and it was characterized by high physical activity level (z-score = 0.56), high calorie-rich snack consumption (z-score = 0.64), and high sugar-sweetened beverages consumption (z-score = 0.57). The means and standard deviations of lifestyle behaviours for each cluster are presented in Table 2.

Table 1. Characteristics of children and their mothers (*n* = 4059).

Characteristic		**Finding**	**Missing**
		n **(%)**	***n*** **(%)**
Social characteristics			
Maternal educational level	Low	420 (10.4)	25 (0.6)
	Mid-low	1215 (30.1)	
	Mid-high	1162 (28.8)	
	High	1237 (30.7)	
Net household income	Low	727 (18.9)	211 (5.2)
	Middle	1036 (26.9)	
	High	2085 (54.2)	
Maternal age at child birth, years, mean (SD)		31.1 (4.8)	0
Children's characteristics			
Sex	Boy	2057 (50.7)	0
	Girl	2002 (49.3)	
Age, years (SD)		6.0 (0.4)	0
Ethnic background	Western	3040 (74.9)	2 (0.05)
	Non-western	1017 (25.1)	
Weight status	Overweight/obesity	536 (14.5)	373 (9.2)
	Normal weight	3150 (85.5)	

The table is based on a non-imputed dataset.

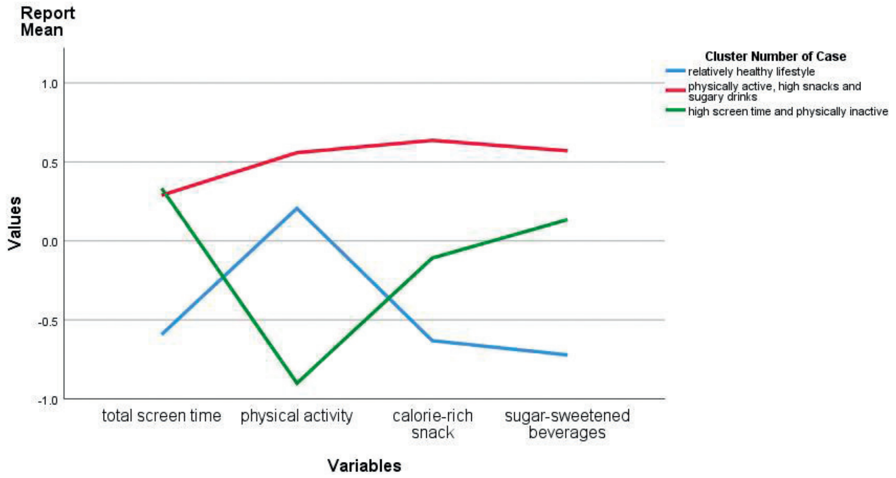

Figure 1. Z-scores of clusters on child lifestyle behaviours in participants from the Generation R Study.

Cluster Distribution according to Child Characteristics and Socioeconomic Status
Table 3 presents the cluster distribution according to child characteristics and SES indicators. Boys were most allocated in the "physically active, high snacks and sugar-sweetened beverages" cluster (54.1%) ($p < 0.001$). The "high screen time and physically inactive" cluster showed the highest proportion of children being overweight/obese (15.9%) ($p < 0.001$). Significant differences in clusters were found by both maternal educational level and net household income ($p < 0.001$). The "relatively healthy lifestyle" cluster showed the highest proportion of children from mothers with a high educational level (40.1%) and children from families with a high-income household (62.9%) ($p < 0.001$). The "high screen time and physically inactive" cluster showed the highest proportion of children from mothers with a mid-low educational level (34.9%) and children from families with a low-income household (27.0%) ($p < 0.001$).

Table 2. Child lifestyle behaviours by cluster distribution (*n* = 4059).

	Cluster 1 "Relatively Healthy Lifestyle"	**Cluster 2 "High Screen Time and Physically Inactive"**	**Cluster 3 "Physically Active, High Snacks and Sugary Drinks"**
	***n* = 1444 (35.6%)**	***n* = 1217 (30.0%)**	***n* = 1398 (34.4%)**
Screen time, mean (SD)	0.99 (0.64)	1.96 (1.10)	1.91 (1.04)
z-score (SE)	−0.59 (0.61)	0.33 (1.05)	0.29 (0.99)
Physical activity, mean (SD)	1.87 (0.96)	0.67 (0.37)	2.26 (1.05)
z-score (SE)	0.21 (0.88)	−0.90 (0.34)	0.56 (0.96)
Calorie-rich snacks, mean (SD)	0.76 (0.60)	1.25 (0.79)	1.95 (0.72)
z-score (SE)	−0.63 (0.64)	−0.11 (0.84)	0.64 (0.77)
Sugary drinks, mean (SD)	1.33 (0.96)	2.48 (1.13)	3.06 (1.16)
z-score (SE)	−0.72 (0.71)	0.13 (0.84)	0.57 (0.86)

The table is based on a non-imputed dataset.

Table 3. Child lifestyle clusters according to child characteristics and socioeconomic status (*n* = 4059).

		Cluster 1 "Relatively Healthy Lifestyle"	Cluster 2 "High Screen Time and Physically Inactive"	Cluster 3 "Physically Active, High Snacks and Sugary Drinks"	*p*-Value *
		n **(%)**	***n*** **(%)**	***n*** **(%)**	
Sex	Boy	676 (46.8)	624 (51.3)	757 (54.1)	<0.001
	Girl	768 (53.2)	593 (48.7)	641 (45.9)	
Weight status	Overweight/obesity	181 (14.0)	178 (15.9)	177 (13.9)	<0.001
	Normal weight	1114 (86.0)	938 (84.1)	1098 (86.1)	
Maternal educational level	Low	73 (5.1)	165 (13.7)	182 (13.7)	<0.001
	Mid-low	329 (22.9)	420 (34.9)	466 (33.5)	
	Mid-high	459 (31.9)	321 (26.6)	382 (27.4)	
	High	576 (40.1)	299 (24.8)	362 (26.0)	
Net household income	Low	178 (13.1)	314 (27.0)	235 (17.7)	<0.001
	Middle	327 (24.0)	323 (27.8)	386 (29.2)	
	High	857 (62.9)	525 (45.2)	703 (53.1)	

The table is based on a non-imputed dataset. * *p*-value is calculated by chi-square test.

Associations of SES Indicators with the Cluster Distribution

Table 4 presents the results from multinomial logistic regression models for the associations between SES indicators and the lifestyle behaviour clusters among children. An adjusted *p*-value [$p = 0.05/(3 \times 2) = 0/008$] was applied since a three-cluster solution was identified. Compared to children of mothers with a high educational level, children of mothers with a low educational level had an OR of 0.28 (95% CI: 0.21, 0.37) to be allocated in the "relatively healthy lifestyle" cluster. On the contrary, compared to children of mothers with a high educational level, children of mothers with a low educational level had an OR of 1.45 (95% CI: 1.13, 1.86) to be allocated in the "high screen time and physically inactive" cluster and an OR of 2.28 (95% CI: 1.79, 2.90) to be in the "physically active, high snacks and sugary drinks" cluster.

Compared to children from high-income households, children from low-income households had an OR of 0.59 (95% CI: 0.48, 0.74) to be allocated in the "relatively healthy lifestyle" cluster and an OR of 1.57 (95% CI: 1.27, 1.94) for the "high screen time and physically inactive" cluster.

Table 4. The association of socioeconomic status with child lifestyle clusters at age 6.

		Cluster 1 "Relatively Healthy Lifestyle"	Cluster 2 "High Screen Time and Physically Inactive"	Cluster 3 "Physically Active, High Snacks and Sugary Drinks"
		OR (95% CI)	OR (95% CI)	OR (95% CI)
Maternal educational level	Low	**0.28 (0.21, 0.37)**	**1.45 (1.13, 1.86)**	**2.28 (1.79, 2.90)**
	Mid-low	**0.46 (0.39, 0.55)**	**1.37 (1.14, 1.64)**	**1.69 (1.42, 2.01)**
	Mid-high	**0.77 (0.66, 0.91)**	1.11 (0.92, 1.34)	1.23 (1.04, 1.47)
	High	Ref	Ref	Ref
Net household income	Low	**0.59 (0.48, 0.74)**	**1.57 (1.27, 1.94)**	1.07 (0.87, 1.31)
	Middle	**0.72 (0.61, 0.84)**	1.18 (0.99, 1.40)	1.22 (1.05, 1.43)
	High	Ref	Ref	Ref

The table is based on an imputed dataset. Models adjusted for child age, gender, ethnic background, and BMI. Bold print indicates statistical significance ($p = 0.05/6 = 0.008$).

Discussion

In this study, we explored clusters of lifestyle behaviours in a large sample of six-year-old children in the Netherlands. Healthy or unhealthy levels of lifestyle behaviours co-occurred in some groups. Three clusters were observed: "relatively healthy lifestyle", "high screen time and physically inactive", and "physically active, high snacks and sugary drinks". Children from high educated mothers or high-income households were more likely to be allocated to the "relatively healthy lifestyle" cluster, while children of low educated mothers or from low-income households were more likely to be allocated to the "high screen time and physically inactive" cluster.

More than one third of the children in our study sample were allocated to the "relatively healthy lifestyle" cluster. Children in this cluster, on average, achieved more than 1 h/day of physical activity [28]. Total screen time use was, on average, below the recommended 2 h/day [29]. On average, children in this cluster consumed one portion of calorie-rich snack and one portion of sugar-sweetened beverage per day, which was the lowest amount in all three clusters observed. Similar types of clusters defined by low sedentary behaviour and low snack and beverage consumption have been observed by other studies among children of different ages as well [9, 11, 30]. For example, Bel-Serrat et al. reported that a "low beverage consumption and low sedentary" cluster was observed among children aged three to six years living in eight European countries [30]. Another study conducted by Bel-Serrat et al. identified a "low beverage intake, low sedentary, and physically active" cluster among children aged six to nine years living in 17 European countries [9]. Matias et al. observed a "health-promoting sedentary behaviour and diet" cluster in a sample of over 100,000 children aged 14 years in Brazil [11]. In addition, we found that the “relatively healthy lifestyle” was more likely to be observed in children of mothers with a high educational level or children from a high-income household. Parents with high SES may be more inclined to use and adhere to information concerning healthy lifestyles and be more competent to offer healthy choices to their younger children compared to low SES parents [13].

Children in the “high screen time and physically inactive” cluster have the lowest level of physical activity of the three observed clusters. Although the average screen time use was just about 2 h/day, it was the highest level of the three clusters. Such displacement between sedentary behaviour and physical activity has been reported in previous studies [10, 23]. A systematic review showed that among several studies, many clusters were defined by high levels of sedentary behaviour [4]. Regardless of being combined with other healthy/unhealthy lifestyle behaviours or not, clusters defined by high levels of sedentary behaviour were associated with an increased risk of overweight/obesity [9].

Consistent with previous studies [4, 10], we found that the “high screen time and physically inactive” cluster was more likely to be observed in children of mothers with a low educational level or children from a low-income household. A study conducted among children from seven European countries aged 10–12 years old also found that children with low educated parents were more likely to be allocated to a low activity/sedentary cluster or sedentary and sugared drinks cluster [23]. These results demonstrated that children from low SES backgrounds tend to be more prevalent in clusters combining multiple unhealthy lifestyles. In our study, sports participation was assessed and included as one form of physical activity. For low SES parents of young children, the lack of resources to sign their children up for a sports activity (e.g., football, judo, gymnastics, jazz, ballet, tennis, etc.) might play an important role. This may explain the social inequality we found in the “high screen time and physically inactive” cluster. In addition, our results showed that a higher proportion of boys were in the “high screen time and physically inactive” cluster, unlike in a systematic review which reported that girls were more likely to be in the low physical activity clusters [4]. Meanwhile, our results also showed that boys were more often in the “physically active, high snacks and sugary drinks” cluster. One possible explanation is that the gender differences in physical activity may link to the child’s age. Previous studies were mostly conducted in older children or adolescents. The gender differences in physical activity were larger in adolescents than in younger children [31]. Furthermore, boys and girls have been shown to have different sedentary behaviour [32]. We observed similar results that boys spent more time watching television and playing computer games than girls, which may explain the higher proportion of boys in the “high screen time and physically inactive” cluster. Future studies may use the information from this study to develop and evaluate programs that use clusters of lifestyle behaviours in order to provide support to children and their families.

In this study, high physical activity level was observed co-existing with high calorie-rich snacks and sugary drinks consumption. To the best of our knowledge, this is the first study to identify a "physically active, high snacks and sugary drinks" cluster in children at this young age group. The co-occurrence of high physical activity and high calorie-rich snacks and drinks consumption is consistent with a review in adults that reported exercise-induced increase in energy intake is typically compensated for by energy-dense food and drinks [33]. Consumption of calorie-rich snacks and sugary drinks may attenuate the beneficial effects of physical activity on skeletal mass [34] and the maintenance of body weight [33]. We also found that children of mothers with low educational level had higher odds of being allocated in the "physically active, high snacks and sugary drinks" cluster, but household income was not associated with being allocated to this cluster. It has been suggested that parental educational level has an independent association with child lifestyle behaviours [35, 36]. Educational level could reflect the level of parental knowledge on healthy lifestyle behaviours and therewith impact the availability and opportunity for children to engage in healthy lifestyle behaviours [37]. This is especially relevant for young school-aged children, who still spend most of their time at home and are less affected by peer behaviour, as compared to older school-aged children. The co-occurrence of high physical activity and high calorie-rich snacks and drinks consumption exists in adults [38], and this could impact parental practices related to healthy lifestyle behaviours. Further research is warranted to confirm the findings of this cluster in relatively young children. In addition, examining how the clustering of lifestyle behaviours progresses over time from a younger age can provide more insight into the changes of children's lifestyle behaviours.

Methodological Considerations

The main strength of our study is the availability of information on lifestyle behaviours in a large sample of school-aged children. Some limitations should be considered. First, net household income was measured via a self-reported questionnaire, and therefore social desirability cannot be excluded. Around 5% of the data was missing. It cannot be ascertained whether an individual tends to over-report or under-report the household income. Second, all child lifestyle behaviours included in the current study were self-reported by the parents, which may have led to bias. Parents' reports of physical activity may have been underestimated as outdoor play and sports participation may also occur in settings outside the home environment (e.g., school and after-school care). Although detailed frequency and duration/portion of each behaviour was measured in the questionnaire, and separately for weekdays and weekends, other measures of children's lifestyle behaviours such as diaries or the use of activity trackers can provide additional information in future research. Research is needed to examine the possibilities of using the identification of clusters of lifestyle behaviour in youth health care practice. Third, only children with complete data on four lifestyle behaviours were included in the study population. Particular characteristics of the excluded participants may bias the cluster distribution. Finally, the causality for the associations of SES with lifestyle behaviour clusters cannot be established from observational studies only. Future studies are needed to establish causal relationships.

Conclusions

Our study showed three clusters of co-occurring patterns with regard to screen time, physical activity, and energy-dense food intake among children aged six years in the Netherlands. Only one third of the children were allocated to the relatively healthy cluster. Other clusters identified showed healthy or unhealthy trends in co-occurrence with lifestyle behaviours. A higher maternal educational level was associated with higher odds for the child to be allocated to the relatively healthy lifestyle behaviour cluster. Children from low-income households were more likely to be allocated to one of the relatively unhealthy lifestyle behaviour clusters, compared to children from a high-income household. Intervention development and prevention strategies may use this information to further target programs promoting healthy behaviours of children and their families.

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CHAPTER 3

Socioeconomic differences in children's television viewing trajectory: a population-based prospective cohort study

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Abstract

We aimed to evaluate the association between family socioeconomic status and repeatedly measured child television viewing time from early childhood to the school period. We analyzed data on 3,561 Dutch children from the Generation R Study, a population-based study in the Netherlands. Parent-reported television viewing time for children aged 2, 3, 4, 6 and 9 years were collected by questionnaires sent from April 2004 until January 2015. Odds ratios of watching television ≥1 hour/day at each age were calculated for children of mothers with low, mid-low, mid-high and high (reference group) education and children from low, middle and high (reference group) income households. A generalized logistic mixed model was used to assess the association between family socioeconomic status and child television viewing time trajectory. The percentage of children watching television ≥1 hour/day increased from age 2 to 9 years for all children (24.2%-85.0% for children of low-educated mothers; 4.7%-61.4% for children of high-educated mothers; 17.2%-74.9% for children from low income households; 6.2%-65.1% for children from high income households). Independent socioeconomic effect in child television viewing time was found for maternal educational level. The interaction between net household income and child age in longitudinal analyses was significant ($p=0.01$), indicating that the television viewing time trajectories were different in household income subgroups. However the interaction between maternal educational level and child age was not significant ($p=0.19$). Inverse socioeconomic gradients in child television viewing time were found from the preschool period to the late school period. The educational differences between the various educational subgroups remained stable with increasing age, but the differences between household income groups changed over time. Intervention developers and healthcare practitioners need to raise awareness among non-highly educated parents that the socioeconomic gradient in television viewing time has a tracking effect starting from preschool age.

Introduction

Sedentary behaviors, including screen-related behaviors (i.e. watching television [TV] and playing computer / electronic games) and non-screen related behaviors (i.e. reading), are highly prevalent during childhood [1, 2]. As a key children's sedentary leisure time pursuit, parent-reported screen time behavior has been linked with adverse health outcomes in childhood including obesity [3], cardiovascular diseases and increased metabolic risk [4, 5]. Given the adverse health outcomes, there are recommendations to limit screen time in childhood. The recommendation from the American Academy of Pediatrics limits screen use to 1 hour per day in children 2 to 5 years of age [6]. Australia and Canada government health authority guidelines recommend that children aged 5-12 years should spend no more than 2 hours a day on electronic media for entertainment [7, 8]. Nonetheless, the majority of young children exceed the recommended levels [9, 10]. Although media use has changed over the past decade aided by the increase in video games and mobile phone use, evidence suggests that the most common screen time behavior continues to be TV viewing[2]. Children who watch more TV at young childhood tend to stay high level of TV viewing time in adolescence [11, 12]. Furthermore, a 32-year follow-up study reported that childhood TV viewing time tracked into adulthood [13]. Little is known about the TV viewing time trajectory from early childhood (i.e. preschool age) to late childhood (i.e. school age, early adolescence) [14]. Longitudinal studies evaluating child TV viewing time trajectory may provide important information to policy makers and researchers regarding the optimal timing of preventive interventions aimed to reduce screen time in childhood.

In addition to identifying important periods in the development of TV viewing behavior, it is important to identify those children who are at increased risk of high levels of TV viewing, and that would benefit from interventions the most. The socioeconomic inequalities in TV viewing time have been well documented, but results have been inconsistent [15]. e.g. According to one study, children (aged 6 to 11) of non-highly-educated mothers were more likely to watch more TV than children of highly-educated mothers [16]. Similarly, another study reported that among children aged 8-to-11-years, those from higher socioeconomic status (SES) groups spent less time watching TV than children from low SES groups [17]. On the other hand, a Greek study reported an inverse association between maternal educational level and TV viewing time among children aged 1-2 years but not among children aged 3-5 years [18]. Furthermore, most of the performed studies are cross-sectional in design [15], and little is known about how socioeconomic inequalities in TV viewing time evolve longitudinally [19].

The aims of the present study were threefold. First, we aimed to assess TV viewing time from early childhood (age 2 years) to the school period (age 9 years). Second, we aimed to assess the cross-sectional association between family SES and TV viewing time with data available at 5 points in time (ages 2, 3, 4, 6 and 9 years). Third, we aimed to evaluate the longitudinal association between family SES and child TV viewing time trajectory from child age 2 to 9 years. We hypothesized that child TV viewing time would increase over time, across all socioeconomic subgroups. We hypothesized that the TV viewing time trajectories would be different for socioeconomic subgroups.

Methods

Study design

This study was embedded in The Generation R Study, a population-based prospective cohort study from fetal life onwards [20]. Midwifes and obstetricians invited all pregnant women under their care with an expected delivery date between April 2002 and January 2006, living in Rotterdam, the Netherlands, at time of delivery to participate in the Generation R Study. More details on the study design and participant inclusion procedure can be found in the design paper by Jaddoe et al [21]. The study was conducted in accordance with the guidelines proposed in the World Medical Association Declaration of Helsinki and has been approved by the Medical Ethical Committee at Erasmus MC, University Medical Center Rotterdam. Written informed consent was obtained from all participants.

Study population

Consent for postnatal follow-up during the preschool period (0-4 years) and/or the school period (6 and 9 years) onwards was available for 4432 children of Dutch mothers. Mothers were considered to be Dutch when both of her parents were born in the Netherlands [22]. We excluded children with missing information on television viewing at all measuring time points (n=467). To avoid clustering of data, we further excluded second (n=365) and third children (n=9) of the same mother, leaving a study population of 3561 participants.

Family socioeconomic status

Our indicators of family SES were maternal educational level and net household income. The highest educational level attained by the mother was collected using questionnaires at enrollment. The Dutch Standard Classification of Education was used to categorize 4 levels of education: high (university or PhD degree) (n=1164), mid-high (higher vocational training) (n=929), mid-low (>3 years general secondary school, intermediate vocational training) (n=911) and low (no education, primary school, lower vocational training, intermediate general school, or 3 years or less general secondary school) (n=441) [23]. Net household income was assessed using questionnaires at child age 2 years and classified into 3 categories: high (>€3300 per month) (n=1378), middle (€2000-3300 per month) (n=1026) and low (<€2000 per month) (n=352) [24].

Television viewing time

Parent-reported TV viewing time was assessed at 5 measuring time points (child age 2, 3, 4, 6 and 9 years). The questionnaires were intended for the mother. If the mother was not able to complete the questionnaire, it could be completed by the other parent/caregiver. Parents were asked to indicate the mean duration per day their child spent on TV viewing in a multiple-choice question (i.e. 1-2 hours). Subsequently, they were asked about the average number of days per week or/and weekends their child spent time on TV viewing (i.e. 2 days per week). We assigned the middle number of hours (e.g. 1.5 hours for "1-2 hours") to each category, as the duration of TV viewing per session. The average TV time per day was derived by multiplying the duration per day by the number of days of TV viewing, which was then divided by seven. Week- and weekend days were combined. However, the number of days of TV viewing was not available at child age 2 and 3 years. Therefore, at age 2 and 3 years we used the number of days of TV viewing at age 4 years when calculating the average TV time per day. At age 4, 51% of parents indicated that their children watched TV seven days per week. Other details on the TV viewing time measures are available in the supplemental material S1 Table. TV viewing time was dichotomized at more than or equal to 1 hour per day according to the latest recommendation from the American Academy of Pediatrics [6]. Sensitivity analyses using a secondary outcome variable dichotomized at 2 hours/day was also performed [7, 8]. Results are available in the supplemental material S2 Table, S1 and S2 Figs.

Potential confounders

Child's gender, age, single parenthood (single parent, two parents [not necessarily biological parents]), presence of siblings and maternal age were considered potential confounders in the associations of family SES with child's TV viewing time. Child's age was obtained by questionnaires at each measuring time point. Single parenthood and maternal age were obtained by a questionnaire at enrollment. Presence of siblings was assessed by a questionnaire at child age 6 years.

Statistical analyses

Descriptive statistics were used to describe the study population. The cross-sectional associations between family SES and child dichotomized TV viewing time at each measuring time point were assessed using logistic regression models. Child's gender and age were included as confounders in the models based on previous literature [15]. Maternal age led to a substantial change in effect estimates (i.e. $\geq$10% change) and was included in the models as confounder as well [25]. The first model included the indicator of family SES and confounders (i.e. two basic models, one for each indicator). The second model assessed the independent effect of the family SES indicator, adjusting for the other SES indicator and confounders (i.e. one full model). Collinearity between maternal educational level and net household income was evaluated by Spearman's rho correlation coefficients ($r=0.47$). The correlation coefficient did not indicate collinearity ($r>0.6$) and therefore both variables were included in the full models simultaneously. A multiple imputation procedure was used to impute missing values in the covariates (ranging from 0% to 28.2%, see Table 1) [26]. Five imputed datasets were generated using a fully conditional specified model, based on the relationships between all the variables included in this study. Cross-sectional analyses of the association between indicators of family SES and child dichotomized TV viewing time at each measuring time point were performed on both the non-imputed and imputed datasets and the results were comparable between two datasets. Pooled estimates from these five imputed datasets were used to report odds ratios (ORs) and their 95% confidence intervals (CI). A significance level of $p<0.05$ was taken to indicate a significant association.

Generalized logistic mixed models (GLMM) were used to assess the association between family SES and child TV viewing time measured repeatedly at age 2, 3, 4, 6 and 9 years. Family SES indicators were added into the GLMM models separately. The best fitting model structure was:

$$log \frac{\pi_{ij}}{1-\pi_{ij}} = \beta_0 + \beta_1 * family\ SES + \beta_2 * child\ age + \beta_3 * child\ age * family\ SES + b_i$$

In this model, π_{ij}= probability of watching TV more than or equal to 1 hour/day. The p-value of the interaction between family SES and child age indicated whether socioeconomic differences changed with the age of the child.

Descriptive analyses and cross-sectional analyses were performed using Statistical Package of Social Science (SPSS) version 21.0 for Windows (SPSS Inc, Chicago, IL, USA) and longitudinal models were fitted using package lme4 in R version 3.2.5 for Windows (R Foundation for Statistical Computing).

Results

Study population characteristics

Table 1 shows characteristics of the study population. At enrollment, 33.8% of the mothers had a high educational level and 12.8% had a low educational level. Of all children, 12.8% of the children belonged to a family with a low household income and 50.0% of the children belonged to a family with a high household income. The percentage of children watching TV ≥1 hour/day increased from age 2 to 9 years. 10.0% of children watched TV more than or equal to 1 hour/day at age 2 years, while at age 9 years, 69.8% of children watched TV more than or equal to 1 hour/day.

TV viewing time from early childhood to the school period

Table 2 shows the percentages of children watching ≥1 hour TV/day according to family SES at each age. The percentage of children watching TV ≥1 hour/day increased from age 2 to 9 years for all SES subgroups. The percentage increased from 24.2% to 85.0% for children of low-educated mothers and from 4.7% to 61.4% for children of high-educated mothers. The percentage increased from 17.2% to 74.9% for children from low income households and from 6.2% to 65.1% for children from high income households.

Table 1. General characteristics of the study population (n=3561)

		Total	Missing
		N (%)	**N (%)**
Family characteristics			
Maternal educational level	High	1164 (33.8)	116 (3.3)
	Mid-high	929 (27.0)	
	Mid-low	911 (26.4)	
	Low	441 (12.8)	
Net household income	More than €3300/month	1378 (50.0)	805 (22.6)
	€2000-3300/month	1026 (37.2)	
	Less than €2000/month	352 (12.8)	
Single parenthood	Yes	199 (5.8)	159 (4.5)
	No	3203 (94.2)	
Maternal age	Years (mean, SD)	31.9 (4.4)	0
Siblings	Yes	2670 (82.6)	327 (9.2)
	No	564 (17.4)	
Child characteristics			
Child's exact age	Age 2 years	24.4 (1.1)	658 (18.5)
Months (mean, SD)	Age 3 years	36.5 (1.1)	806 (22.6)
	Age 4 years	48.5 (1.0)	728 (20.4)
	Age 6 years	71.8 (4.8)	262 (7.4)
	Age 9 years	116.2 (3.4)	613 (17.2)
Gender	Girl	1766 (49.6)	0
	Boy	1795 (50.4)	
TV viewing time ≥1 hour/day	Age 2 years	266 (10.0)	913 (25.6)
	Age 3 years	704 (27.5)	1004 (28.2)
	Age 4 years	906 (32.4)	764 (21.5)
	Age 6 years	1652 (52.9)	436 (12.2)
	Age 9 years	1858 (69.8)	900 (25.3)
TV viewing time ≥2 hour/day	Age 2 years	0 (0)	913 (25.6)
	Age 3 years	100 (3.9)	1004 (28.2)
	Age 4 years	154 (5.5)	764 (21.5)
	Age 6 years	361 (11.6)	436 (12.2)
	Age 9 years	643 (24.2)	900 (25.3)

Table is based on non-imputed dataset.
Values are means (SD) for normally distributed continuous variables and frequencies (percentage) for categorical variables.

Table 2. TV viewing time ≥1 hour/day according to family socioeconomic status (n=3561)

		TV viewing time ≥1 hour/day N (%)				
		Age 2 years	Age 3 years	Age 4 years	Age 6 years	Age 9 years
Maternal educational level	High	46 (4.7)	165 (17.2)	221 (21.6)	451 (43.8)	553 (61.4)
	Mid-high	65 (8.6)	198 (27.0)	242 (30.7)	405 (48.6)	476 (66.0)
	Mid-low	93 (14.5)	214 (35.0)	281 (40.9)	466 (59.6)	529 (77.0)
	Low	59 (24.2)	115 (51.6)	144 (55.4)	263 (71.1)	238 (85.0)
p-value*		**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Net household income	>€3300/month	79 (6.2)	257 (21.2)	313 (24.4)	568 (46.5)	698 (65.1)
	€2000-3300/month	120 (12.8)	282 (32.8)	344 (36.6)	496 (54.4)	563 (69.9)
	<€2000/month	52 (17.2)	100 (35.7)	142 (46.4)	172 (58.3)	188 (74.9)
p-value*		**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.004**

Table is based on non-imputed dataset.
*p-value assessed by Chi-square tests.

Table 3. Associations of family socioeconomic status with TV viewing time (≥1 hour/day) at each age (n=3561)

		TV viewing time ≥1 hour/day				
		Age 2 years	Age 3 years	Age 4 years	Age 6 years	Age 9 years
Basic model*						
Maternal educational level	High	1	1	1	1	1
	Mid-high	**1.90**	**1.80**	**1.61**	**1.25**	**1.25**
		(1.28, 2.81)	**(1.42, 2.28)**	**(1.30, 2.00)**	**(1.04, 1.50)**	**(1.02, 1.54)**
	Mid-low	**3.37**	**2.61**	**2.48**	**1.95**	**2.24**
		(2.32, 4.91)	**(2.05, 3.31)**	**(2.00, 3.08)**	**(1.60, 2.37)**	**(1.78, 2.82)**
	Low	**6.32**	**5.20**	**4.41**	**3.15**	**3.90**
		(4.12, 9.67)	**(3.79, 7.14)**	**(3.29, 5.91)**	**(2.42, 4.11)**	**(2.69, 5.63)**

Table 3. Continued.

		TV viewing time ≥1 hour/day				
		Age 2 years	Age 3 years	Age 4 years	Age 6 years	Age 9 years
Net household income	>€3300/month	1	1	1	1	1
	€2000-3300/month	**2.12**	**1.79**	**1.70**	**1.40**	**1.30**
		(1.57, 2.87)	**(1.46, 2.19)**	**(1.39, 2.08)**	**(1.19, 1.65)**	**(1.08, 1.56)**
	<€2000/month	**2.88**	**1.93**	**2.46**	**1.60**	**1.87**
		(1.98, 4.21)	**(1.46, 2.57)**	**(1.90, 3.17)**	**(1.24, 2.06)**	**(1.37, 2.55)**
Full model[**]						
Maternal educational level	High	1	1	1	1	1
	Mid-high	**1.68**	**1.68**	**1.47**	1.21	1.23
		(1.12, 2.51)	**(1.32, 2.14)**	**(1.18, 1.84)**	(1.00, 1.47)	(0.99, 1.53)
	Mid-low	**2.82**	**2.38**	**2.16**	**1.86**	**2.18**
		(1.89, 4.22)	**(1.84, 3.08)**	**(1.71, 2.73)**	**(1.50, 2.32)**	**(1.70, 2.80)**
	Low	**4.94**	**4.69**	**3.58**	**3.01**	**3.69**
		(3.09, 7.88)	**(3.32, 6.62)**	**(2.61, 4.91)**	**(2.24, 4.04)**	**(2.49, 4.02)**
Net household income	>€3300/month	1	1	1	1	1
	€2000-3300/month	**1.47**	**1.30**	**1.29**	1.12	1.01
		(1.06, 2.03)	**(1.04, 1.62)**	**(1.04, 1.61)**	(0.94, 1.35)	(0.82, 1.24)
	<€2000/month	**1.58**	1.12	**1.56**	1.06	1.16
		(1.04, 2.39)	(0.82, 1.52)	**(1.18, 2.07)**	(0.80, 1.41)	(0.83, 1.63)

Table is based on imputed dataset. Bold print indicates statistical significance. Values represent odds ratios and 95% confidence intervals derived from multiple logistic regression analyses.
[*] Adjusted for confounders (i.e. child's gender and exact age at measurement and maternal age at enrollment).
[**] Additional adjusted for the other family socioeconomic status indicators.

Cross-sectional association between family socioeconomic status and child TV viewing time

Children of low-, mid-low-, and mid-high-educated mothers were more likely to watch TV ≥1 hour/day compared to children of high-educated mothers at all ages (all p<0.05) (basic model, Table 3). The OR for TV viewing time ≥1 hour/day for children of low-educated mothers was 6.32 (95% CI: 4.12, 9.67) at age 2 years, 5.20 (95% CI: 3.79, 7.14) at age 3 years, 4.41 (95% CI: 3.29, 5.91) at age 4 years, 3.15 (95% CI: 2.42, 4.11) at age 6 years and 3.90 (95%CI: 2.69, 5.63) at age 9 years. Children of low-, and middle-household income families were more likely to watch TV ≥1 hour/day compared to children of high household income families (all p<0.05). The OR for TV viewing time ≥1 hour/day for children from low income households was 2.88 (95% CI: 1.98, 4.21) at age 2 years, 1.93 (95% CI: 1.46, 2.57) at age 3 years, 2.46 (95% CI: 1.90, 3.17) at age 4 years, 1.60 (95% CI: 1.24, 2.06) at age 6 years and 1.87 (95%CI: 1.37, 2.55) at age 9 years. With both SES indicators in the model (full model, Table 3), independent associations with child TV viewing time were found for maternal educational level at all ages and for net household income only at child age 2 and 4 years.

Longitudinal association between family socioeconomic status and the child TV viewing time trajectory

Because of the missing values of TV viewing time at each measuring time point (12.2% to 28.2%, see Table 1), a total of 17,805 measurements of TV viewing time were available over 5 time points. Results from our GLMM models showed that the probability of TV viewing time ≥1 hour/day increased over time for all socioeconomic subgroups (Fig 1 and 2). Fig 1 and 2 showed all lines increasing from age 2 to age 9. The interaction term between maternal educational level and child age was not significant (p=0.19), indicating that TV viewing time trajectories were not significantly different for the educational subgroups (Fig 1). The interaction term between net household income and child age was significant (p=0.01), indicating that children from different income households subgroups showed a different TV viewing time trajectory (Fig 2).

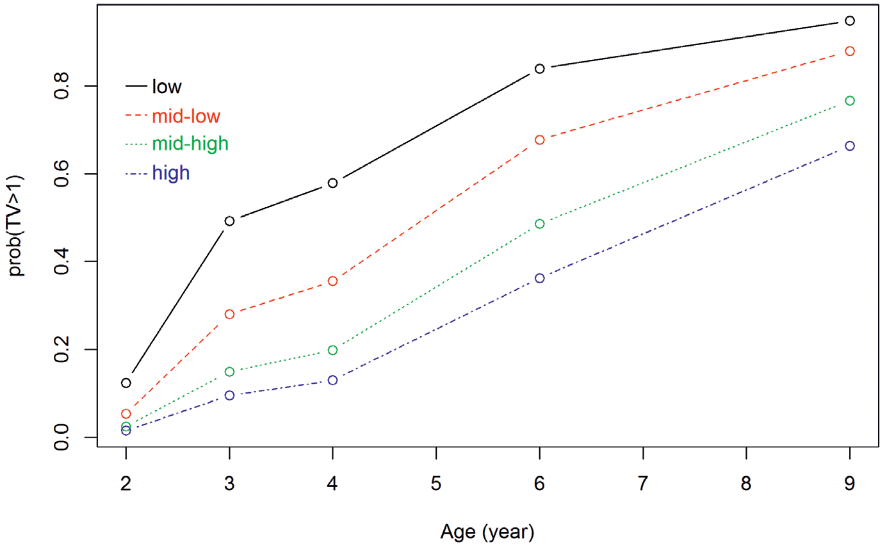

Fig 1. Association between maternal educational level and TV viewing time trajectory
Results are based on generalized logistic mixed model and reflect the probability of watching TV ≥1 hour/day (based on 17805 measurements) in the first 9 years of children of low-, mid-low-, mid-high- and high-educated mother.

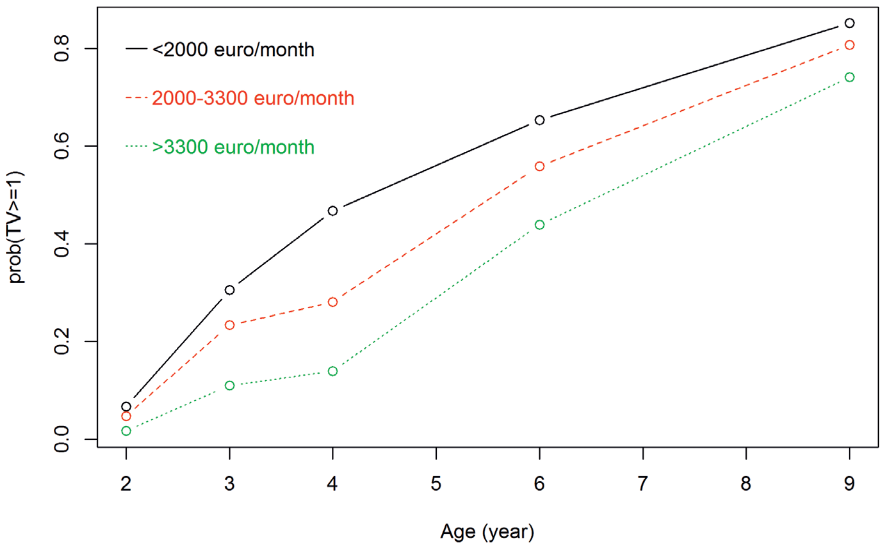

Fig 2. Association between net household income and TV viewing time trajectory
Results are based on generalized logistic mixed model and reflect the probability of watching TV ≥1 hour/day (based on 17805 measurements) in the first 9 years of children from low-, mid- and high-income households.

Associations with TV viewing time ≥2 hours/day

In addition, we evaluated the associations between family SES and child TV viewing time with a secondary outcome variable dichotomized at 2 hours/day. In our study population, there were no children watch TV ≥2 hours/day at age 2 years (Table 1). The results of the cross-sectional analyses were comparable to the previous analyses, although effect estimates (ORs) were larger. Again, children of low educated mothers showed the highest risk watching TV ≥2hours/day (3 years: OR=8.47, 95% CI: 3.96, 18.10; 4 years: OR=11.46, 95% CI: 6.42, 20.43; 6 years: OR=5.36, 95% CI: 3.69, 7.78; 9 years: OR=5.21, 95%CI: 3.83, 7.09). The OR for TV viewing time ≥2 hours/day for children from low income households was 2.67 (95% CI: 1.45, 4.93) at age 3 years, 3.95 (95% CI: 2.46, 6.33) at age 4 years, 3.18 (95% CI: 2.07, 4.91) at age 6 years and 2.69 (95%CI: 2.03, 3.58) at age 9 years (basic model, S2 Table). Independent associations with child TV viewing time were found for maternal educational level at all ages and for household income except at child age 3 years (full model, S2 Table). In longitudinal analyses, both interaction terms for maternal educational level and net household income (p=0.41 and p=0.20, respectively) were not significant (S1 and S2 Figs).

Discussion

Results from this longitudinal study supported the hypothesis that for children in all the socioeconomic subgroups, TV viewing time increases from age 2 to 9 years. Compared with children from high SES subgroups, children from low SES subgroups were more likely to exceed entertainment-media guidelines (<1 hour/day) at all ages, as expected. The TV viewing trajectories differed significantly between children from high, middle and low income households. However TV viewing trajectories did not differ significantly between children of low-, mid-low-, mid-high- or high-educated mothers, which was not expected.

The finding that number of children engaging in TV viewing time ≥ 1 hour daily increased significantly from age 2 to 9 years confirms previous reports on increases in screen-based entertainment use that occurs during early childhood [18, 27]. An American National Survey reported that the total proportion of young people engaged in TV/video viewing ≥ 2 hours daily was 35.3% for 2-5 years and 49.1% for 6-11 years [27]. In addition, the increase of child TV viewing time we found in all SES groups from age 2 to 9 years is supported by a recent Swedish study, which found that in 7-to-9-year-old school children sedentary behavior increased in both high and low SES groups [19]. Even though children have access to a variety of entertainment media, TV viewing remains the predominant source of children's screen-based entertainment and sedentary behaviors [28]. Different sedentary behaviors may influence child health differently, however TV viewing is most strongly linked to overweight development. One study reported that TV viewing was associated with overweight; non-school computer usage and reading were not [29]. Another study reported the bi-directional relationship between TV viewing and overweight [30]. Therefore, limiting TV viewing is still a key target for public health intervention in children, especially for preschoolers and school-aged children.

Our finding of associations between family SES and child TV viewing time is in line with studies showing that low SES children more often have a higher TV viewing time than high SES children have [17, 31, 32]. In addition, we found the inverse socioeconomic differences in child TV viewing time at each measuring time points, i.e. age 2, 3, 4, 6 and 9 years. Large socioeconomic differences in TV viewing time occurred as early as age 2 years, and continued: by age 9 years, children of low-educated mothers were four times more likely to be exceeding entertainment-media guidelines (<1 hour/day). These findings differ from results from a study among Greek preschoolers (1-5 years), which found an inverse association between maternal educational level and TV viewing time among children aged 1-2 years but not among children aged 3-5 years [18]. Possible explanations for the discrepancy are that the trajectories of TV viewing time across maternal educational subgroups may vary between countries. Further, TV viewing time was dichotomized at more than or equal to 2 hours per day in the Greek study, which makes the result less prominent for children age under 5 years. Independent associations with child TV viewing time were found in maternal educational level at all ages but not in household income at later ages. One possible explanation for our findings with regard to income, is that children who are in day-care may spend less time watching TV than children who are cared for at home [33]. After the first years (e.g. age 0-4 years in the Netherlands), all children, from both low and high income families, attend primary school. Additional analyses of our data on day-care attendance at the age of 3 years, suggested indeed that children from high income households were more often in day-care ≥ 2 days/week compared to children from low income households. Future studies are recommended to further explore these findings, with regard to the potential explanatory mechanisms. Maternal educational differences in TV viewing remained until age 9 years, which indicates that maternal educational level has an independent role in the socioeconomic differences in child TV viewing behavior.

The present study is a large-scale study assessing socioeconomic inequalities in child TV viewing time trajectory from preschoolers to older school-aged children. Results from our GLMM models showed that the difference in probability of exceeding entertainment-media guidelines (<1 hour/day) between the various educational subgroups remained stable with increasing age, but the differences between the various income subgroups narrowed with increasing age. The socioeconomic differences in TV viewing occurred as early as age 2 years and remained until age 9 years. The association between family SES and child TV viewing time has been found to be mediated by parental attitudes and practices (e.g. availability of media in the bedroom, screen time with parents) [15, 34]. These parenting behaviors offer opportunities for intervention. However more research is needed to investigate the exact impact of these mediating factors in the pathway between SES and child TV viewing. Contrary to the primary outcome of TV≥1 hour/day in the longitudinal associations, the interaction term between child age and net household income was not significant in the sensitivity analyses. In the primary outcome, TV viewing time appeared to differ across socioeconomic subgroups at age 3 and 4 years (Fig 2). During this time period, watching TV no more than 1 hour/day is recommended by all regulations [6, 35, 36]. In our study, the cut-off of TV ≥1 hour/day was more sensitive in capturing the socioeconomic differences in child TV viewing trajectory.

Our results emphasize the need to develop and evaluate interventions for child TV viewing in early childhood. In early childhood socioeconomic differences appeared to be the strongest and interventions most warranted. Early intervention is important to eliminate socioeconomic inequalities in child TV viewing developing. However, not only early childhood but also adolescence may be an important period to intervene. Future studies are recommended to study the development of socioeconomic inequalities in TV viewing time through adolescence, especially taking into consideration the availability of alternative screen-time behaviors. In addition, it is important for policy makers to understand the cumulative effect on children's health of long-term or short-term exposure to low family SES. However, very few studies have clarified this question and there is a lack of evidence on the influence of children's TV viewing [37]. Future studies are recommended to study whether periods of low family SES have a greater impact at some life stages than at others. Furthermore, pathways (i.e. parental attitudes and practices, child day-care attendances and availability of alternative screen time sources) underlying the association between family SES and child TV viewing time may be different at different ages, so merit future studies.

Methodological considerations

Strengths of this study include the large sample of children of different socioeconomic background and the availability of data on repeatedly measured TV viewing time at five time points during childhood. Several limitations of this study should be considered when interpreting the results. First, children with missing data on all five time points of TV viewing time (n=467) were compared with children that had at least one data point (n=3965) using Chi-square test for gender, maternal educational level and net household income. Data were more often missing for children with a low maternal educational level ($\chi^2 = 376$, df = 3, $p < 0.001$) and children from family with low household income ($\chi^2 = 48$, df = 2, $p < 0.001$). This could have led to selection bias, if children with missing data on all five time points watched more TV than the children that we included. Second, potential information bias due to social desirable answering (i.e. the tendency for individuals to overreport desirable behaviors and underreport undesirable behaviors) may have been introduced by the use of parent-reported questionnaires [38]. It is possible that high-educated mothers are more likely to recognize the stigma associated with excessive TV viewing and thus underreport their child's behavior. Therefore, it is possible that the observed associations underestimated the true associations. Another possible limitation is that information on child television time was derived from 2-4 items in parent-reported questionnaires. Other forms of assessment (e.g. direct observations) are considered to be superior to a few items in a questionnaire [39]. Furthermore, information bias in the outcome variables may have occurred due to the use of different items in questionnaires at each age (see S1 Table). We used the number of days of TV viewing at age 4 years to calculate daily TV viewing time at age 2 and 3 years. This may have introduced information bias. Children at age 2 and 3 may have watched more or less days TV per week than at age 4 years. In this study, maternal educational level and net household income served as indicators of family SES. These variables have been shown to be consistently inversely associated with child TV viewing time [16, 31, 40]. Misclassification of net household income may have occurred since €3300 per month may be a low cut off for high income group, which may lead to an underestimation of income differences in children's TV viewing time. However, as we have not collected the information on net household income above €3300 per month, this is difficult to ascertain. Furthermore, misclassification of family SES may have occurred after long time follow-up. The indicators of family SES were repeatedly collected at child age 6 years. Compared to the family SES at enrollment, 11% of the mothers had improved their educational level. With regard to net household income, 25.5% of the families changed from lower household income to higher household income and 4.7% family changed from higher household income to lower household income. We repeated the cross-sectional analyses between family SES, measured at child age 6 years, and child TV viewing time at age 6 and at 9 years. The results were comparable to the analyses using family SES at enrollment/child age 2 years, although effect estimates were slightly larger (S3 Table). Our study was conducted in a large sample of Dutch children, therefore future studies are recommended to study the socioeconomic differences in children's TV viewing trajectory in other large varied population.

Conclusion

In conclusion, child TV viewing time increases from the preschool period to the school period in all socioeconomic subgroups. During this time, independent inverse effect was found in maternal educational level at all ages but not in net household income. The educational differences between the various educational subgroups remained stable with increasing age, but the differences between household-income groups changed over time. Future studies need to follow-up on the associations between family SES and child TV viewing time when children develop and reach adolescence. Also, underlying pathways associated with family SES and child TV viewing time need to be assessed in, preferably, longitudinal research. Intervention development and healthcare practitioners need to raise awareness among non-highly educated parents about the tracking effect of socioeconomic differences in television viewing time starting from preschool children.

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Table S1. Questionnaire items and calculation of the TV viewing time

Age (measuring time point)	Question	Response Scale (assigned value)	Label	TV viewing time
2 (1)	How long on average, does your child watch TV per day during the week?	Never (0), less than 0.5 hours (0.25), 0.5 hours to 1 hour (0.75), more than 1 hour (1.5)	A_2	TVtime@2 = (A_2 * 5 + B_2 * 2) / 7 * D_4/ 7 ①
	How long on average, does your child watch TV per day during the weekend?	Less than 1 hour (0.5), 1 hour to 2 hours (1.5), more than 2 hours (2.5)	B_2	
3 (2)	How much time has your child been occupied with watching television in the last month (On most weekdays)?	None or less than 30 minutes per day (0.25), 30 minutes to 1 hour per day (0.75), 1 to 2 hours per day (1.5), 2 to 3 hours per day (2.5), more than 3 hours per day (3.5)	A_3	TVtime@3 = (A_3*5 + B_3*2)/7* D_4/7 ①
	How much time has your child been occupied with watching television in the last month (During the weekend)?	None or less than 30 minutes per day (0.25), 30 minutes to 1 hour per day (0.75), 1 to 2 hours per day (1.5), 2 to 3 hours per day (2.5), more than 3 hours per day (3.5)	B_3	
4 (3)	How many days per week does your child watch TV/Video/ DVD?②	Never, less than 1 day per week (0), 1 day per week (1), 2 days per week (2), 3 days per week (3), 4 days per week (4), 5 days per week (5), 6 days per week (6)	D_4	TVtime@4 = D_4 * T_4/ 7
	How long does your child generally watch TV/Video/DVD per day for?	Less than half an hour per day (0.25), between half an hour and 1 hour per day (0.75), 1 to 2 hours per day (1.5), 2 to 3 hours per day (2.5), more than 3 hours per day (3.5)	T_4	

Table S1. Continued.

Age (measuring time point)	Question	Response Scale (assigned value)	Label	TV viewing time
6 (4) and 9 (5)	On average, how many weekdays per week does your child watch television/video/DVD?	Never on weekdays (0), 1 day (1), 2 days (2), 3 days (3), 4 days (4), every weekday (5)	D_{6i} D_{9i}	TVtime@6 = $[(A_{6i} + A_{6j} + A_{6m}) * D_{6i} + (B_{6i} + B_{6j} + B_{6m}) * D_{6j}] / 7$
	On average, how many weekend days per week does your child watch television/video/DVD?	Never in the weekend (0), 1 day in the weekend (1),2 days in the weekend (2)	D_{6j} D_{9j}	TVtime@9 = $[(A_{9i} + A_{9j} + A_{9m}) * D_{9i} + (B_{9i} + B_{9j} + B_{9m}) * D_{9j}] / 7$
	On the days that your child watches television/video/DVD, how long does he watch, on average? Differentiate here between weekdays and week-ends. - Weekday mornings - Weekday afternoons - Weekday evenings after dinner - weekend mornings - Weekend afternoons - Weekend evenings after dinner	Never (0), less than 30 minutes (0.25), 30-60 minutes (0.75), 1-2 hours (1.5), 2-3 hours (2.5), 3-4 hours (3.5)	A_{6i} A_{6j} A_{6m} B_{6i} B_{6j} B_{6m} A_{9i} A_{9j} A_{9m} B_{9i} B_{9j} B_{9m}	

① At age 2 and 3 years we used the number of days of TV viewing at age 4 years when calculating the average TV time per day.

② At age 4, 51% of parents indicated that their children watched TV seven days per week.

Chapter 3

Table S2. Associations of family socioeconomic status with TV viewing time (≥2 hours/day) at each age (n=3561)

		TV viewing time ≥2 hour/day			
		Age 3 years	Age 4 years	Age 6 years	Age 9 years
Basic model*					
Maternal educational level	High	1	1	1	1
	Mid-high	**3.30 (1.62, 6.71)**	**2.03 (1.11, 3.70)**	**1.67 (1.17, 2.39)**	**1.37 (1.05, 1.77)**
	Mid-low	**6.08 (3.07, 12.04)**	**4.96 (2.87, 8.56)**	**2.96 (2.10, 4.17)**	**2.75 (2.13, 3.54)**
	Low	**8.47 (3.96, 18.10)**	**11.46 (6.42, 20.43)**	**5.36 (3.69, 7.78)**	**5.21 (3.83, 7.09)**
Net household income	>€3300/ month	1	1	1	1
	€2000-3300/ month	**2.02 (1.23, 3.31)**	**2.25 (1.47, 3.46)**	**1.86 (1.36, 2.54)**	**1.59 (1.25, 2.13)**
	<€2000/ month	**2.67 (1.45, 4.93)**	**3.95 (2.46, 6.33)**	**3.18 (2.07, 4.91)**	**2.69 (2.03, 3.58)**
Full model**					
Maternal educational level	High	1	1	1	1
	Mid-high	**3.08 (1.48, 6.38)**	1.81 (0.98, 3.35)	1.48 (1.00, 2.19)	1.27 (0.97, 1.67)
	Mid-low	**5.51 (2.70, 11.25)**	**4.16 (2.34, 7.41)**	**2.45 (1.62, 3.71)**	**2.46 (1.88, 3.22)**
	Low	**7.31 (3.20, 16.69)**	**8.82 (4.70, 16.58)**	**4.03 (2.56, 6.33)**	**4.33 (3.10, 6.03)**
Net household income	>€3300/ month	1	1	1	1
	€2000-3300/ month	1.23 (0.73, 2.08)	1.34 (0.85, 2.13)	1.34 (0.93, 1.93)	1.16 (0.90, 1.49)
	<€2000/ month	1.31 (0.67, 2.55)	**1.75 (1.04, 2.95)**	**1.85 (1.11, 3.10)**	**1.54 (1.12, 2.10)**

Table is based on imputed dataset. Bold print indicates statistical significance. Values represent odds ratios and 95% confidence intervals derived from multiple logistic regression analyses.
* Adjusted for confounders (i.e. child's gender and exact age at measurement and maternal age at enrollment).
** Additional adjusted for the other family socioeconomic status indicators.

Table S3. Associations of family socioeconomic status (at child age 6 years) with TV viewing time (n=3561)

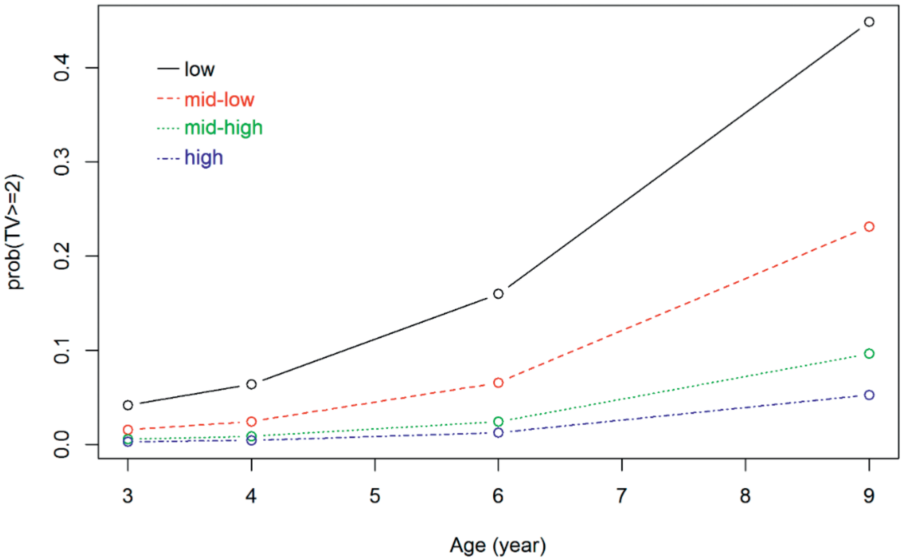
		TV viewing time ≥1 hour/day	
		Age 6 years	Age 9 years
Basic model*			
Maternal educational level***	High	1	1
	Mid-high	**1.30**	**1.41**
		(1.09, 1.55)	**(1.14, 1.75)**
	Mid-low	**2.44**	**1.64**
		(2.01, 2.97)	**(1.30, 2.06)**
	Low	**3.82**	**3.69**
		(2.76, 5.28)	**(2.47, 5.53)**
Net household income***	>€3300/month	1	1
	€2000-3300/month	**1.35**	**1.31**
		(1.13, 1.61)	**(1.05, 1.62)**
	<€2000/month	**1.77**	**1.68**
		(1.37, 2.27)	**(1.22, 2.31)**
Full model**			
Maternal educational level	High	**1**	**1**
	Mid-high	**1.27**	**1.30**
		(1.06, 1.53)	**(1.06, 1.61)**
	Mid-low	**2.35**	**2.51**
		(1.90, 2.92)	**(1.93, 3.26)**
	Low	**3.64**	**3.88**
		(2.54, 5.23)	**(2.29, 6.59)**
Net household income	>€3300/month	**1**	**1**
	€2000-3300/month	0.99	0.97
		(0.82, 1.20)	(0.77, 1.23)
	<€2000/month	1.21	1.11
		(0.92, 1.58)	(0.79, 1.56)

Table is based on imputed dataset. Bold print indicates statistical significance. Values represent odds ratios and 95% confidence intervals derived from multiple logistic regression analyses.

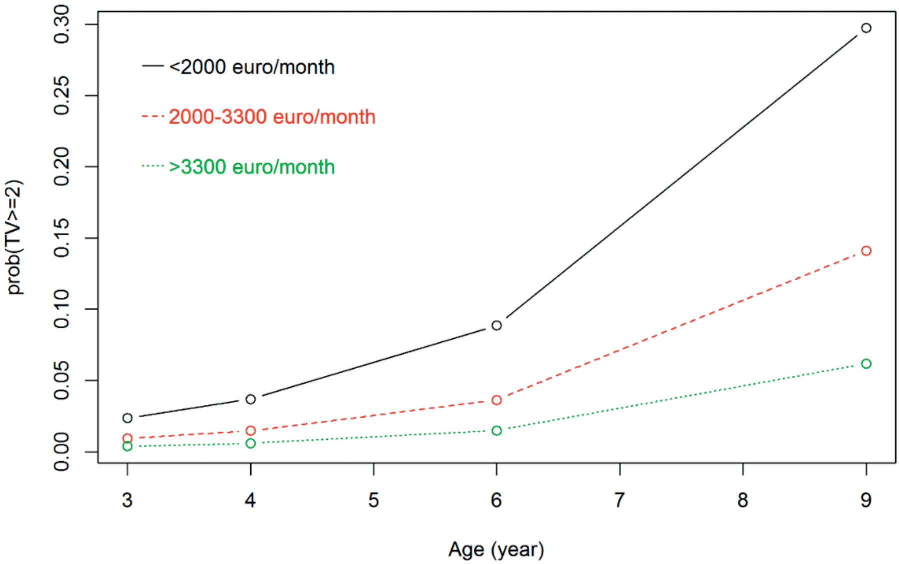
* Adjusted for confounders (i.e. child's gender and exact age at measurement and maternal age at enrollment).

** Additional adjusted for the other family socioeconomic status indicators.

*** Maternal educational level and net household income were collected at child age 6 years.



S1 Fig. Association between maternal educational level and TV viewing time (≥2 hour/day) trajectory.
Results are based on generalized logistic mixed model and reflect the probability of watching TV ≥2 hours/day (based on 14244 measurements) from age 3 to 9 years of children of low-, mid-low-, mid-high- and high-educated mother.



S2 Fig. Association between net household income and TV viewing time (≥2 hour/day) trajectory.
Results are based on generalized logistic mixed model and reflect the probability of watching TV ≥2 hours/day (based on 14244 measurements) from age 3 to 9 years of children from low-, mid- and high-income households.

CHAPTER 4

Ethnic background and children's television viewing trajectories: the Generation R Study

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Abstract

This study, conducted in the Netherlands, evaluated the association between ethnic background and children's TV viewing time at multiple time points and its trajectory. We analyzed 4,833 children with a Dutch, Moroccan, Turkish, or Surinamese ethnic background from the Generation R Study, a population-based study in the Netherlands. Parent-reported television viewing time for children at ages 2, 3, 4, 6, and 9 years was collected by questionnaires sent from April 2004 until January 2015. Odds ratios of watching television ≥1 hour/day at each age were calculated for children from the various ethnic backgrounds. Generalized logistic mixed models (GLMMs) were used to assess the association between ethnic background and television viewing time trajectory. The effect modification by family socioeconomic status was examined in cross-sectional and longitudinal analyses. The percentage of children viewing television ≥1 hour/day increased from age 2 to 9 years for children from all ethnic backgrounds. After adjusting for maternal educational level and net household income, children from all ethnic subgroups had greater odds of watching television ≥1 hour/day at some time points compared with children with a Dutch background (Surinamese: all ages; Moroccan: at ages 4 and 6 years; Turkish: at ages 4 and 9 years). The GLMMs indicated that television viewing trajectories differed between ethnic subgroups. The associations between ethnic background and children's television viewing time were moderated by maternal educational level for child ages 4 and 6 years ($p < 0.05$). In longitudinal analyses, the ethnic differences in probability of watching television ≥1 hour/day were larger in children from high-educated mothers than in children from low-educated mothers. In conclusion, ethnic differences in television viewing time were present at all measuring time points. The discrepancy between children with a Dutch background and children with another background was larger in high maternal educational subgroups.

Introduction

Multiple studies have shown that excessive screen time contributes to the risk of childhood overweight and obesity [1]. Currently, health authorities in Australia and Canada recommend children aged 5-12 years spend no more than 2 hours a day on electronic media for entertainment [2, 3]. For children 2 to 5 years of age, the American Academy of Pediatrics advises limiting screen use to 1 hour per day [4]. Nonetheless, there remains room for improving the screen use behavior in most young children [5, 6]. Despite the development of new media technologies over the past 10 years, television (TV) viewing is still the predominant screen time behavior for young children [7]. Such early life behavior has been shown to persist across age , indicating that children spending more time viewing TV when they are young are more likely to spend more time viewing TV later in adolescence [8, 9]. Children who spend much time on TV viewing also spend more time using other media such as video games, computers, and smartphones [10]. A study investigating different sedentary behaviors found that they influenced child health differently and that TV viewing was most strongly related to the overweight development [11]. The increasing amount of time children spent viewing TV and the potential implications of TV viewing on health outcomes highlight the importance of preventing excessive TV viewing behavior in early life.

Ethnic differences in childhood overweight have been reported in several country settings [12, 13]. In the Netherlands, the prevalence of overweight and obesity is much higher among children with a Turkish and Moroccan background than among native Dutch children [14]. Furthermore, studies in other countries have revealed that ethnic minority groups spend more time watching TV than their native counterparts [15, 16]. However, little is known about the differences in TV viewing time between children from different ethnic backgrounds in the Netherlands [17]. Moreover, longitudinal studies on the development of TV viewing time among children with different ethnic backgrounds may provide important information to policy makers and researchers regarding the optimal age as well as which groups to target with preventive interventions aimed at reducing TV viewing time.

Our study had three aims. The first was to evaluate the associations between ethnic background and children's TV viewing time at multiple time points: ages 2, 3, 4, 6, and 9 years. We hypothesized that children with a non-Dutch ethnic background would have higher TV viewing time than children with a Dutch background. The second aim was to assess the association between ethnic background and children's TV viewing trajectory, i.e., TV viewing time over multiple time points. We hypothesized that TV viewing trajectories would differ between subgroups with a different ethnic background. The third aim was to examine to what extent the associations between child ethnic background and TV viewing time were modified by socioeconomic differences. On the basis of our previous findings [17], we hypothesized that there would be significant effect modification by family socioeconomic status (SES) (i.e., maternal educational level).

Methods

Study design

This study was embedded in the Generation R Study, a population-based prospective cohort study from fetal life until young adulthood in the Netherlands. Pregnant women with an expected delivery date between April 2002 and January 2006 living in Rotterdam were eligible for participation in the study [18]. Extensive assessments are performed in mothers, fathers, and their children. The study was conducted in accordance with the guidelines proposed in the World Medical Association's Declaration of Helsinki and was approved by the Medical Ethical Committee at Erasmus Medical Center, University Medical Center Rotterdam. Written informed consent was obtained from all participants.

Study population

In total, 9,778 mothers were enrolled in the study and gave birth to 9,745 known live born children. Consent for postnatal follow-up during the preschool period (0–4 years) and/or the school period (6–9 years) was available for 9,162 children. For the purpose of this study, we selected children with Dutch, Moroccan, Turkish, or Surinamese ethnic backgrounds (n=6,497). These subgroups were chosen because they represent the largest ethnic background in the Generation R Study as well as in the city of Rotterdam [19]. We excluded participants with missing information on TV viewing at all measuring time points (n=1,209). To avoid clustering of data, we further excluded second (n=446) and third children (n=9) of the same mother, leaving a study population of 4,833 participants. The final population for analysis consisted of 3,561 children with a Dutch background, 317 children with a Moroccan background, 498 children with a Turkish background and 457 children with a Surinamese background (see S1 Appendix).

Ethnic background

The ethnic backgrounds of the mothers and children were categorized with the standard methods used in the Netherlands [20]. The children were assigned to the subgroups as their mothers' ethnic background with the cultural background of the mothers is taken into account. Maternal ethnic background was based on the country of birth of the mother and of her parents; this information was obtained by the questionnaire completed at enrollment. In accordance with Statistics Netherlands, if the mother was born outside the Netherlands, this country of birth determined the ethnic background. If she was born in the Netherlands, but one of her parents was born outside the Netherlands, this country of birth determined the ethnic background. If both her parents were born outside the Netherlands, her mother's country of birth determined her ethnic background.

TV viewing time

Children's TV viewing time was assessed at five time points (child ages 2, 3, 4, 6, and 9 years) by parent-reported questionnaires. Parents were asked about the average number of days per week or/and weekend their child spent viewing TV. Subsequently, they were asked to indicate the average time spent per day viewing TV. We took the duration of TV viewing per session to be the median number of hours (e.g., 1.5 hours in the case of "1–2 hours"). The average TV viewing time per day was derived by multiplying the duration per day by the number of days of TV viewing, which was then divided by seven. Week and weekend days were combined. TV viewing time for children aged 2 or 3 was obtained differently from that of children of other ages, because the number of days of TV viewing was not available for these very young children. To harmonize the measurements, we estimated average TV time for children aged 2 and 3 years from the number of days of TV viewing at age 4 years. 54% of parents indicated that at that age their children watched TV seven days per week. More information on the TV viewing time is available in S1 Table and in an earlier publication [21]. Based on the latest recommendation from the American Academy of Pediatrics [4], TV viewing time was dichotomized at more than or equal to 1 hour per day. Sensitivity analyses using a secondary outcome variable dichotomized at 2 hours per day were also performed [2, 3]. The results are available in S2 Table.

Potential confounders

Child gender, age, marital status, and family SES were considered potential confounders in the associations between ethnic background and children's TV viewing time. Child age was obtained by questionnaires at each measuring time point. Mothers' marital status was assessed by questionnaires at enrollment and dichotomized as married/cohabiting or no partner. Family SES was captured by two following indicators: maternal educational level and net household income. The highest educational level attained by the mother was established using questionnaires at enrollment. The Dutch Standard Classification of Education was used to categorize three levels of education: low (no education, primary school, lower vocational training, intermediate general school, or 3 years or less general secondary school); middle (>3 years general secondary school, intermediate vocational training); and high (higher vocational training, university or PhD degree) [22]. Net household income was assessed by questionnaire at enrollment and classified into two categories: high (>€2,200 per month) and low (less than €2,200 per month) [23]. Sensitivity analyses were performed using paternal educational level as measurement of family SES. The results are available in S3 Table.

Statistical analyses

First, frequency tables and cross tabulations were used to explore characteristics of the study population. The association between child ethnic background and TV viewing time at each measuring time point was assessed cross-sectionally using logistic regression models. Child age, maternal educational level, and net household income led to a substantial change in effect estimates (i.e., ≥10% change) and were included in the models as confounders [24]. Odds ratios (ORs) and 95% confidence intervals (CI) are reported for each subgroup compared to the reference group of children with a Dutch background. A significance level of $p<0.05$ was taken to indicate a significant association between ethnic background and children's TV viewing time. A multiple imputation procedure was used to impute missing values in the covariates (ranging from 0% to 28.2%, see Table 1). Five imputed datasets were generated using a fully conditional specified model, based on the relationships between all the variables included in this study [25]. Pooled estimates from these five imputed datasets were used to report ORs and their 95% CI. Cross-sectional analyses were performed on both the non-imputed and imputed datasets and the results were found to be comparable.

Generalized logistic mixed models (GLMM) were used to assess the association between ethnic background and children's TV viewing time trajectory. These longitudinal models take the correlation between repeated-measured TV viewing time into account and allow for incomplete outcome variables. The p-value ($p<0.05$) of the interaction effect between ethnic background and child age indicated whether socioeconomic differences changed with the age of the child.

To assess effect modification by maternal educational level and net household income, an interaction term between ethnic background and each indicator of family SES was added to the cross-sectional models. For the longitudinal models, the interaction term between ethnic background and each indicator of SES was tested in the GLMM models. Only the significant interaction terms ($p<0.05$) were included in the final models to show TV viewing trajectories in the various SES subgroups.

Descriptive analyses and cross-sectional analyses were performed using the Statistical Package for Social Sciences (SPSS) version 21.0 for Windows (SPSS Inc, Chicago, IL, USA) and longitudinal models were fitted using the lme4 package in R version 3.3.2 for Windows (R Foundation for Statistical Computing).

Results

Participant characteristics

Table 1 shows the characteristics of the study population. Over 25% of the mothers had a non-Dutch ethnic background. Compared to Dutch mothers, non-Dutch mothers were more frequently lower educated and more often had a low household income (less than €2,200/month) (all $p<0.001$). Compared to non-Dutch mothers, Dutch mothers more often were married or cohabiting (94.2% for Dutch mothers versus 85.0% for non-Dutch mothers, $p<0.001$), except for mothers with a Moroccan background (96.7%). For all ethnic subgroups of children, the percentage viewing TV ≥1 hour/day increased from ages 2 to 9 years (from 10.0% to 69.8% for children with a Dutch background;

from 17.4% to 84.8% for children with a Turkish background; from 23.9% to 80.1% for children with a Moroccan background; from 30.2% to 89.0% for children with a Surinamese background). Children from all subgroups had greater odds of exceeding the recommendations on screen use of 1 hour per day compared to children with a Dutch background (all $p < 0.001$).

Associations between ethnic background and children's TV viewing time at ages 2, 3, 4, 6, and 9 years

In the total study population, ethnic background was significantly associated with TV viewing time at all ages (all $p < 0.001$, Table 2). After adjusting for maternal educational level and net household income, children with a Surinamese background had greater odds of watching TV ≥1 hour/day compared with children with a Dutch background at all ages, with the highest risk in the group at age 9 years (OR: 2.65, 95%CI: 1.76, 3.98). Compared with children with a Dutch background, children with a Moroccan background had greater odds of watching TV ≥1 hour/day at age 4 years (OR: 1.63, 95%CI: 1.14, 2.33) and age 6 years (OR: 1.83, 95%CI: 1.30, 2.56), children with a Turkish background had greater odds of watching TV ≥1 hour/day at age 4 years (OR: 1.46, 95%CI: 1.10, 1.95) , age 6 years (OR: 1.38, 95%CI: 1.06, 1.78)and age 9 years (OR: 1.61, 95%CI: 1.06, 2.44).

Effect modifications by family SES

The associations between ethnic background and children's TV viewing time were moderated by maternal educational level at child ages 4 and 6 years ($p < 0.05$). No moderation was observed for net household income. Among children from low-educated mothers, children with a Moroccan background had greater odds of watching TV ≥1 hour/day compared to children with a Dutch background. (OR: 2.14, 95%CI:1.10, 4.19) (Table 3).

Among children from middle-educated mothers and compared to children with a Dutch background, children with a Surinamese background had greater odds of watching TV ≥1 hour/day at all ages except age 3 years; the highest risk was in the group at age 2 years (OR: 2.73, 95%CI: 1.66, 4.48). Children with a Turkish background had greater odds of watching TV ≥1 hour/day at ages 4 years (OR: 1.77, 95%CI: 1.13, 2.79) and 6 years (OR: 1.98, 95%CI: 1.27, 3.08).

Among children from high-educated mothers, children with a Surinamese background had greater odds of watching TV ≥1 hour/day compared to children with a Dutch background at all ages, with the highest risk in the group at age 9 years (OR: 6.74, 95%CI: 2.46, 18.50). The highest risk compared to children with a Dutch background was found in children with a Moroccan or Turkish background at age 4 years (for the Moroccan subgroup, OR: 5.21, 95%CI: 1.87, 14.54; for the Turkish subgroup, OR: 3.10, 95%CI: 1.53, 6.24). Sensitivity analyses using paternal educational level showed that the associations between ethnic background and children's TV viewing time were moderated by paternal educational level at child ages 2, 3, and 6 years ($p < 0.05$). The results were comparable to the analyses using maternal educational level. Among children from low-educated fathers, no significant differences in children's TV viewing time were found between ethnic subgroups (S3 Table).

Table 1. Characteristics of the total study population and per ethnic subgroup (n=4,833)[a]

	Ethnic Background					
	Total N=4,833	**Dutch n=3,561 (73.7%)**	**Turkish n=498 (10.3%)**	**Moroccan n=317 (6.6%)**	**Surinamese n=457 (9.5%)**	**P-value[b]**
Family Characteristics[c]						
Maternal educational level (%)						
Low	20.3	12.8	52.5	47.1	30.4	<0.001
Middle	29.8	26.4	34.4	36.6	48.6	
High	49.9	60.8	13.1	16.3	21.0	
Maternal age years (SD)	31.0 (4.9)	31.9 (4.4)	27.8 (5.1)	29.0 (5.2)	28.9 (5.5)	<0.001
Marital status (%)						
Married/cohabiting	91.8	94.2	93.9	96.7	67.4	<0.001
No partner	8.2	5.8	6.1	3.3	32.6	
Net Household Income (%)						
Less than €2200/month	37.7	25.0	86.9	89.0	64.2	<0.001
> €2200/month	62.3	75.0	13.1	11.0	35.8	
Child Characteristics[c]						
Gender (%)						
Boy	51.1	50.4	52.6	50.2	55.6	0.18
Child's exact age Mean (SD)						
Age 2 years	24.4 (1.1)	24.4 (1.1)	24.6 (1.3)	24.8 (1.3)	24.6 (1.3)	<0.001
Age 3 years	36.6 (1.3)	36.5 (1.1)	37.0 (1.7)	37.0 (1.8)	36.9 (1.7)	<0.001
Age 4 years	48.6 (1.1)	48.5 (1.0)	49.1 (1.6)	49.0 (1.5)	48.9 (1.2)	<0.001
Age 6 years	72.4 (5.5)	71.8 (4.8)	74.3 (6.6)	75.1 (7.8)	73.7 (6.5)	<0.001
Age 9 years	116.5 (3.7)	116.2 (3.4)	117.7 (4.2)	118.5 (5.6)	117.0 (4.0)	<0.001
TV viewing time ≥ 1 hour/day (%)						
Age 2 years	12.3	10.0	17.4	23.9	30.2	<0.001
Age 3 years	30.9	27.5	47.1	50.0	46.7	<0.001
Age 4 years	36.8	32.4	54.5	56.5	54.3	<0.001
Age 6 years	57.6	52.9	70.8	75.6	73.4	<0.001
Age 9 years	72.8	69.8	84.8	80.1	89.0	<0.001

Table 1. Continued.

	Ethnic Background					
	Total N=4,833	**Dutch n=3,561 (73.7%)**	**Turkish n=498 (10.3%)**	**Moroccan n=317 (6.6%)**	**Surinamese n=457 (9.5%)**	**P-value[b]**
TV viewing time ≥ 2 hour/day (%)						
Age 2 years	0	0	0	0	0	-
Age 3 years	6.0	3.9	18.6	14.9	14.3	<0.001
Age 4 years	8.6	5.5	22.0	18.2	21.8	<0.001
Age 6 years	18.2	11.6	39.1	40.3	39.7	<0.001
Age 9 years	29.5	24.2	50.5	46.8	56.1	<0.001

Table is based on non-imputed dataset.

[a] Values are percentages or means (SD) for the total population and per ethnic subgroup.

[b] P-values are calculated by Chi-square test for categorical variables and ANOVA for continuous variables.

[c] Data were missing for maternal educational level (5.5%), household income (21.1%), child's exact age at 2 (26.2%), 3 (29.6%), 4 (26.9%), 6 (9.4%) and 9 (23.7%) years and child TV viewing time at 2 (33.8%), 3 (36.4%), 4 (28.0%), 6 (15.1%) and 9 (31.9%) years.

Associations between ethnic background and children's TV viewing time trajectories

Because at each measuring time point there were missing values for TV viewing time (ranging from 15.1% to 36.4% of the total), for all five time points the total number of measurements of TV viewing time was 16,511. The interaction term between ethnic background and measuring time point, and the interaction between ethnic background and maternal educational level were both significant at p<0.05 and were added to the longitudinal model. The significance of the interaction term between ethnic background and measuring time point indicated that TV viewing trajectories differed significantly between ethnic subgroups. In addition, the significance of the interaction term between ethnic background and maternal educational level indicated that TV viewing trajectories differed significantly at each maternal educational level. Figs 1–3 show the results of the repeated measurement analyses of ethnic background and children's TV viewing time trajectories in children of respectively high-, middle-, and low-educated mothers. The probability of viewing TV ≥1 hour/day increased over time for all ethnic subgroups. The ethnic differences in probability of watching TV ≥1 hour/day were larger in children of high-educated mothers than in children of low-educated mothers.

Table 2. Associations between ethnic background and TV viewing time at each age (n=4,833)

Ethnic background	Measuring time point Age 2 years OR (95%CI)	Age 3 years OR (95%CI)	Age 4 years OR (95%CI)	Age 6 years OR (95%CI)	Age 9 years OR (95%CI)
Dutch	1.00	1.00	1.00	1.00	1.00
Turkish	0.93 (0.62, 1.39)	1.23 (0.89, 1.69)	**1.46 (1.10, 1.95)**	**1.38 (1.06, 1.78)**	**1.61 (1.06, 2.44)**
Moroccan	1.42 (0.88, 2.30)	1.46 (0.97, 2.20)	**1.63 (1.14, 2.33)**	**1.83 (1.30, 2.56)**	1.20 (0.78, 1.85)
Surinamese	**2.38 (1.67, 3.38)**	**1.54 (1.12, 2.13)**	**1.72 (1.30, 2.28)**	**1.83 (1.42, 2.37)**	**2.65 (1.76, 3.98)**

Table is based on imputed dataset. Bold print indicates statistical significance. Values represent odds ratios and 95% confidence intervals derived from multiple logistic regression analyses.
Models were adjusted for child's exact age, maternal educational level, and net household income.

Table 3. Associations of ethnic background with TV viewing time according to maternal educational level at each age (n=4,833)

Maternal educational level	Ethnic background	Measuring time point Age 2 years OR (95%CI)	Age 3 years OR (95%CI)	Age 4 years OR (95%CI)	Age 6 years OR (95%CI)	Age 9 years OR (95%CI)
High	Dutch	1.00	1.00	1.00	1.00	1.00
	Turkish	1.31 (0.39, 4.45)	2.17 (1.00, 4.71)	**3.10 (1.53, 6.24)**	1.85 (0.87, 3.91)	**2.49 (1.02, 6.07)**
	Moroccan	2.19 (0.58, 8.27)	2.28 (0.90, 5.74)	**5.21 (1.87, 14.54)**	**2.21 (1.03, 4.73)**	2.08 (0.86, 5.01)
	Surinamese	**3.77 (1.91, 7.47)**	**2.65 (1.46, 4.81)**	**3.09 (1.80, 5.32)**	**2.45 (1.47, 4.11)**	**6.74 (2.46, 18.50)**
Middle	Dutch	1.00	1.00	1.00	1.00	1.00
	Turkish	1.67 (0.96, 2.90)	1.40 (0.83, 2.35)	**1.77 (1.13, 2.79)**	**1.98 (1.27, 3.08)**	1.63 (0.85, 3.12)
	Moroccan	1.93 (0.92, 4.06)	1.49 (0.76, 2.93)	1.61 (0.89, 2.92)	1.37 (0.83, 2.26)	1.08 (0.54, 2.14)
	Surinamese	**2.73 (1.66, 4.48)**	1.40 (0.88, 2.22)	**1.62 (1.08, 2.41)**	**1.58 (1.09, 2.29)**	**1.89 (1.09, 3.28)**
Low	Dutch	1.00	1.00	1.00	1.00	1.00
	Turkish	**0.41 (0.22, 0.78)**	0.81 (0.51, 1.28)	0.78 (0.52, 1.18)	0.89 (0.60, 1.32)	1.00 (0.85, 3.12)
	Moroccan	0.82 (0.39, 1.70)	1.01 (0.53, 1.90)	0.82 (0.46, 1.46)	**2.14 (1.10, 4.19)**	0.74 (0.36, 1.53)
	Surinamese	1.23 (0.63, 2.39)	0.95 (0.51, 1.79)	0.87 (0.49, 1.53)	1.73 (0.99, 3.01)	1.64 (0.58, 4.61)

Table is based on imputed dataset. Bold print indicates statistical significance. Values represent odds ratios and 95% confidence intervals derived from multiple logistic regression analyses.
Models were adjusted for child's exact age and net household income.

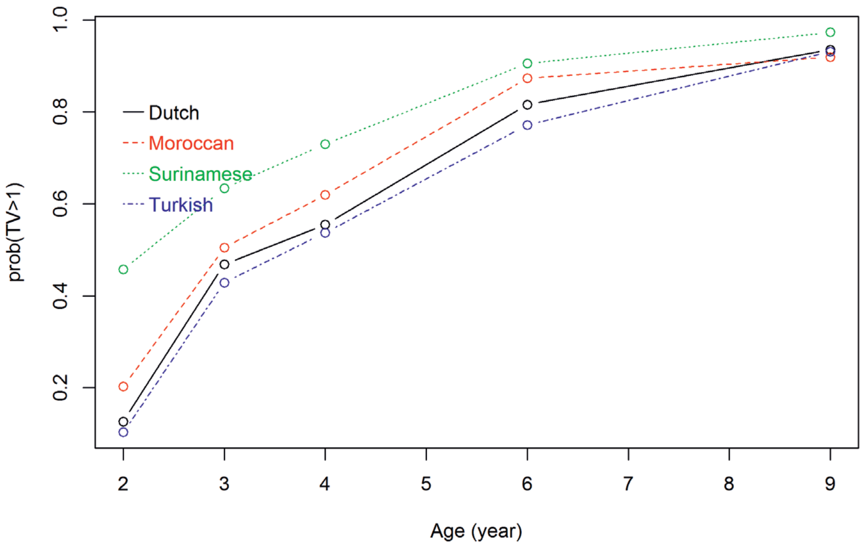

Fig. 1. Association between ethnic background and TV viewing time trajectories in children of low-educated mothers

Results are based on a generalized logistic mixed model and reflect the probability of TV viewing time of >1 hour/day (based on 2,579 measurements) in the first 9 years for children of mothers with low education level.

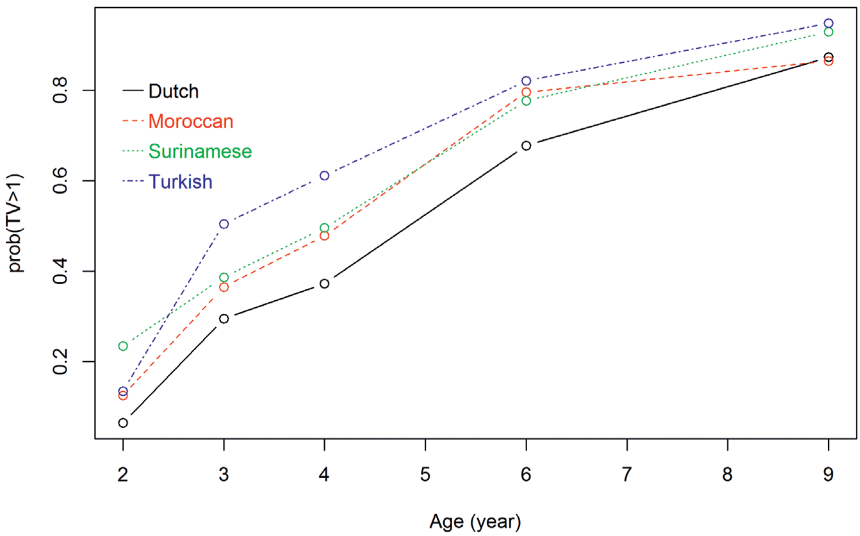

Fig. 2. Association between ethnic background and TV viewing time trajectories in children of middle-educated mothers

Results are based on a generalized logistic mixed model and reflect the probability of TV viewing time of >1 hour/day (based on 4,656 measurements) in the first 9 years for children of mothers with middle education level.

Chapter 4

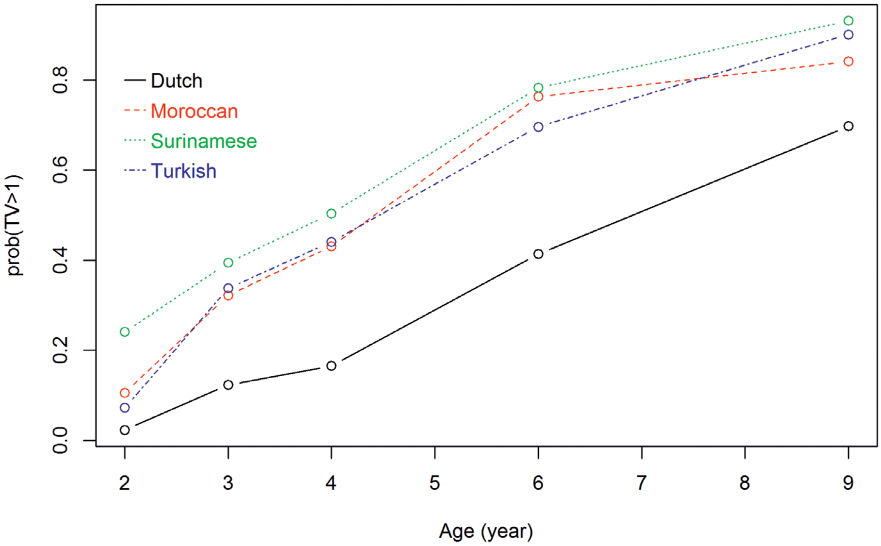

Fig. 3. Association between ethnic background and TV viewing time trajectories in children of high-educated mothers

Results are based on a generalized logistic mixed model and reflect the probability of TV viewing time of >1 hour/day (based on 9,276 measurements) in the first 9 years for children of mothers with high education level.

Discussion

This prospective study aimed to assess the trajectories of children's TV viewing time in an ethnically diverse sample of children from the Netherlands at ages from 2 to 9 years. The study found that in all ethnic subgroups the percentage of children watching TV more than 1 hour/day increased from ages 2 to 9 years. Children with a Turkish, Moroccan, or Surinamese ethnic background had greater odds of exceeding entertainment media guidelines (<1 hour/day) compared to children with a Dutch background, especially at the ages of 4 and 6 years. At these ages, the associations between ethnic background and children's TV viewing time were moderated by maternal educational level. As we hypothesized, the TV viewing trajectories differed among ethnic subgroups. Apart from that, the disparities in trajectory were different at each maternal educational level.

Cross-sectional analyses revealed that children from other ethnic subgroups had greater odds of watching TV more than 1 hour/ day than children with a Dutch background, especially at school age. This is in line with the findings of previous studies conducted among school-aged children [15, 26]. Haughton et al. reported that among children aged 6–11 years in the United States, the percentage of children engaging in ≤ 2 hours of screen time varied across non-Hispanic whites, Hispanics, non-Hispanic blacks, and Asians [15]. A systematic review reported that 17 out of 21 studies found that ethnic background was associated with TV viewing time among children ≤7 years old. Most of the studies found that ethnic minority group was positively strongly associated with TV viewing time [26]. In our study, association between ethnic background and children's TV viewing time was not significant at child age 3 years. Before the age of 4 years, only children with a Surinamese background had greater odds of watching TV ≥1 hour/day compared with children with a Dutch background. These findings differ from an earlier report on trajectories of TV viewing time among preschool children from the UK [27]. In that study of children aged 6–36 months, the children of Pakistani mothers spent around 13 minutes more viewing TV a day than the children of white British mothers [27]. However, as the ethnic backgrounds of people in a country reflect that country's immigration history and culture, the pathways underlying the association between ethnic background and TV viewing time can be expected to differ.

It has been well documented that indicators of family SES (i.e., maternal educational level and net household income) are inversely associated with children's TV viewing time [21, 26]. Mothers who are not highly educated have been reported to display more positive attitudes about TV viewing, believing that TV programs are instructive and stimulating [28]. Our study too found that maternal educational level had a significant effect modification on ethnic differences in TV viewing time: in the high maternal educational level subgroup, the percentage of children watching TV for more than 1 hour a day was significantly lower in the Dutch children than in the children from the other ethnic backgrounds. Moreover, this ethnic difference was absent among children from low-educated mothers. In addition to cross-sectional analyses, effect modification was observed in longitudinal models evaluating TV viewing time trajectories. In the subgroup with low maternal educational level, children with a Turkish background had lower odds of watching TV more than 1 hour/day compared to children with a Dutch background at all ages we considered. The differences were significant at age 2 years but not thereafter. In the subgroup with a high maternal educational level, children with Moroccan and Turkish backgrounds showed similar TV viewing trajectories. Interestingly, in our study the influence of maternal educational level on ethnic differences is stronger for school-age children than for preschool children. This finding is contrary to our expectation that maternal educational level would have a stronger influence when children are younger and less likely to be influenced by the environment outside the home. Future studies might shed more light on this by studying the interaction effect between maternal educational level and ethnic background in TV viewing time among adolescent children.

It has been consistently reported that parental attitude toward TV viewing and home environment factors are associated with higher children's TV viewing time [26]. We found that mothers from all ethnic subgroups watched more TV than Dutch mothers at child age 4 years ($p<0.017$, S4 Table). Apart from parents' own TV viewing time, parental attitude toward children's TV viewing (i.e., allowing a TV set in the child's bedroom) also play an important role in children's TV viewing behavior. Children from all three non-

Dutch ethnic groups more often had a TV set in their bedrooms compared to children with a Dutch background ($p<0.001$ at all measuring time points, S4 Table). At child age 3 years, only 2.0% of children with a Dutch background had a TV set in their bedroom; the highest percentage, 17.5%, was for children with a Moroccan background. At child age 9 years, 18.6% of children with a Dutch background had a TV set in their bedroom; the highest percentage (34.2%) was found for children with a Surinamese background. The percentage of children exceeding the entertainment media viewing guidelines (<1 hour/day) was higher among children with a TV set in their bedroom than among children without a TV set in their bedroom ($p<0.001$ at all measuring time points, S5 Table). These results suggest that in addition to parental education and income, other culturally influenced environmental factors contribute to ethnic differences in children's TV viewing time.

Some longitudinal studies have reported an association between higher TV viewing time and child obesity [29, 30]. It is therefore important to provide policy makers and researchers with information regarding the TV viewing time of population groups. Our findings from trajectory analyses highlight the time points that may be suitable for targeted intervention programs. Interventions should also take into account parents' cultural beliefs and values, as these may impact children's health-related behavior.

Methodological considerations

The strengths of this study include the large sample of children from different ethnic backgrounds and the availability of data on repeatedly measured TV viewing time at five time points over the first nine years of life. The longitudinal design enabled trajectories to be plotted and the identification of a key time point and population groups that may be suitable for targeted intervention programs. Several limitations of this study should be considered when interpreting the results. First, about 19% of the participants who were eligible for inclusion in this study based on their ethnic background were excluded from the analyses because data were not available on TV viewing time for all five time points. Nonresponse analyses showed that data for all five time points were more often missing for children from ethnic minority groups and low SES groups. Selection bias may have occurred if the association between ethnic background and TV viewing time differed between participants and nonparticipants. Second, in this study the parental country of birth plays a central role in the definition of child/maternal ethnic background. The definition we use implies ethnic background based on the ethnic origin of the study population, not on their nationality and/or ethnic identity. Future studies are recommended to take more components of ethnic background into account. Third, as information on children's TV viewing time was derived from parent-reported questionnaires, socially desirable answers (i.e., the over-reporting of favorable behaviors) cannot be excluded. Furthermore, information bias in the TV viewing time may have occurred due to the use of different items in questionnaires at each age (see S1 Table). We used the number of days of TV viewing at age 4 years to estimate daily TV viewing time at ages 2 and 3 years. This may have introduced information bias. Children at ages 2 and 3 may have watched TV on more or fewer days per week than at age 4 years. Furthermore, sensitivity analyses using TV viewing time dichotomized at 2 hours per day were performed on data at ages 6 and 9 years. The results of the cross-sectional analyses were comparable to the previous analyses, although the effect estimates (ORs) were larger (see S2 Table). Sensitivity analyses were not performed on data at ages 2 to 4 years because it is always recommended that this age group watches TV for no more than 1 h/day. Also, in our study population the sample of children watching TV for more than 2 hours per day is relatively small. None of the children watched TV ≥2 hours/day at age 2 years (Table 1).

Conclusions

To sum up: the percentage of children watching TV more than 1 hour/day increased from age 2 to 9 years for these children with Dutch, Turkish, Moroccan, and Surinamese backgrounds. The ethnic differences in TV viewing time were present at all measuring time points. The children's TV viewing trajectories differed among ethnic subgroups at each maternal educational level. The gap between children with a Dutch background and children with a different ethnic background was larger in high maternal educational subgroups. Our results suggest that interventions intended to reduce TV viewing time should target children of non-Dutch ethnic groups and their parents when the children are at an early age. Future studies are recommended to follow adolescents' TV viewing trajectories and the association with ethnic background.

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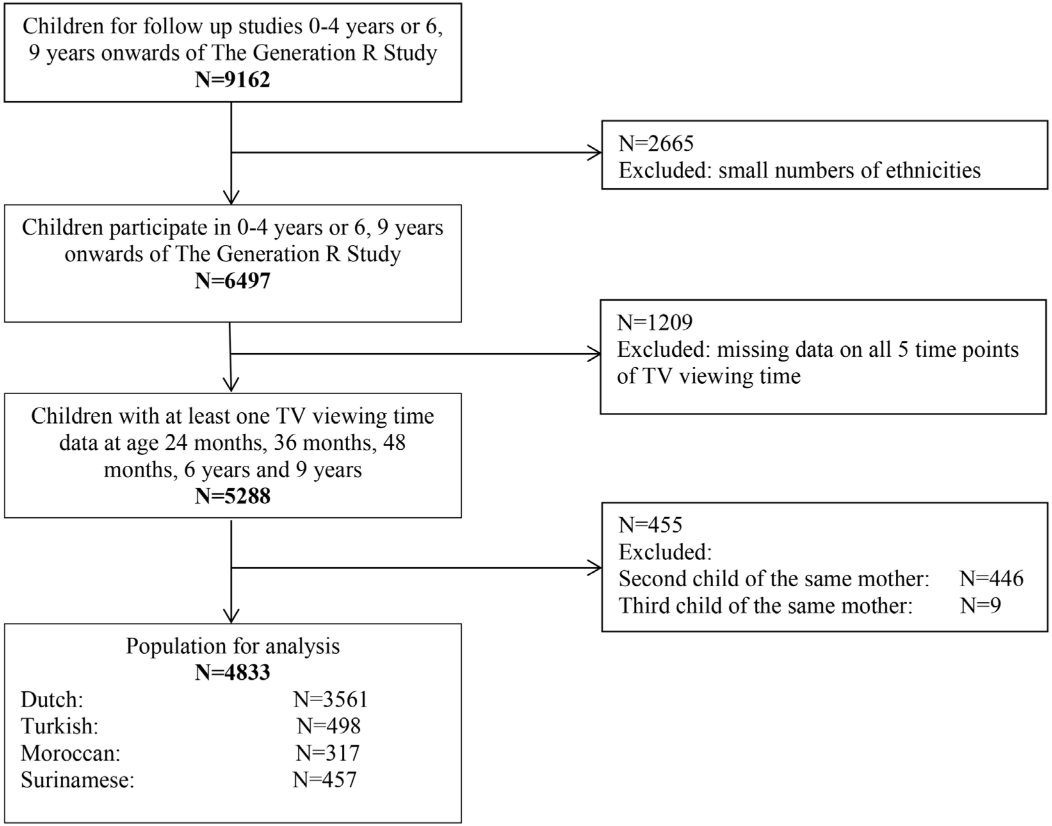


S1 Appendix. Flowchart of participants included for analysis

S1 Table. Questionnaire items and calculation of the TV viewing time

Age (measuring time point)	Question	Response Scale (assigned value)	Label	TV viewing time
2 (1)	How long on average, does your child watch TV per day during the week?	Never (0), less than 0.5 hours (0.25), 0.5 hours to 1 hour (0.75), more than 1 hour (1.5)	A_2	TVtime@2 = $(A_2 * 5 + B_2 * 2) / 7 * D_4 / 7$ ①
	How long on average, does your child watch TV per day during the weekend?	Less than 1 hour (0.5), 1 hour to 2 hours (1.5), more than 2 hours (2.5)	B_2	
3 (2)	How much time has your child been occupied with watching television in the last month (On most weekdays)?	None or less than 30 minutes per day (0.25), 30 minutes to 1 hour per day (0.75), 1 to 2 hours per day (1.5), 2 to 3 hours per day (2.5), more than 3 hours per day (3.5)	A_3	TVtime@3 = $(A_3 * 5 + B_3 * 2)/7 * D_4/7$ ①
	How much time has your child been occupied with watching television in the last month (During the weekend)?	None or less than 30 minutes per day (0.25), 30 minutes to 1 hour per day (0.75), 1 to 2 hours per day (1.5), 2 to 3 hours per day (2.5), more than 3 hours per day (3.5)	B_3	
4 (3)	How many days per week does your child watch TV/Video/DVD?②	Never, less than 1 day per week (0), 1 day per week (1), 2 days per week (2), 3 days per week (3), 4 days per week (4), 5 days per week (5), 6 days per week (6)	D_4	TVtime@4 = $D_4 * T_4 / 7$
	How long does your child generally watch TV/Video/DVD per day for?	Less than half an hour per day (0.25), between half an hour and 1 hour per day (0.75), 1 to 2 hours per day (1.5), 2 to 3 hours per day (2.5), more than 3 hours per day (3.5)	T_4	

S1 Table. Continued.

Age (measuring time point)	Question	Response Scale (assigned value)	Label	TV viewing time
6 (4) and 9 (5)	On average, how many weekdays per week does your child watch television/video/DVD?	Never on weekdays (0), 1 day (1), 2 days (2), 3 days (3), 4 days (4), every weekday (5)	D_{6i} D_{9i}	TVtime@6 = $[(A_{6i} + A_{6j} + A_{6m}) * D_{6i} + (B_{6i} + B_{6j} + B_{6m}) * D_{6j}] / 7$
	On average, how many weekend days per week does your child watch television/video/DVD?	Never in the weekend (0), 1 day in the weekend (1),2 days in the weekend (2)	D_{6j} D_{9j}	TVtime@9 = $[(A_{9i} + A_{9j} + A_{9m}) * D_{9i} + (B_{9i} + B_{9j} + B_{9m}) * D_{9j}] / 7$
	On the days that your child watches television/video/DVD, how long does he watch, on average? Differentiate here between weekdays and week-ends. - Weekday mornings - Weekday afternoons - Weekday evenings after dinner - weekend mornings - Weekend afternoons - Weekend evenings after dinner	Never (0), less than 30 minutes (0.25), 30-60 minutes (0.75), 1-2 hours (1.5), 2-3 hours (2.5), 3-4 hours (3.5)	A_{6i} A_{6j} A_{6m} B_{6i} B_{6j} B_{6m} A_{9i} A_{9j} A_{9m} B_{9i} B_{9j} B_{9m}	

① At age 2 and 3 years we used the number of days of TV viewing at age 4 years when calculating the average TV time per day.

② At age 4, 51% of parents indicated that their children watched TV seven days per week.

S2 Table. Associations of ethnic background with TV viewing time (≥ 2 hours/day) according to maternal educational level at age 6 and 9 years (n=4,833)

	Ethnic background	**Measuring time point**	
		Age 6 years	**Age 9 years**
		OR (95%CI)	**OR (95%CI)**
Total study population[a]	Dutch	1.00	1.00
	Turkish	**2.49 (1.90, 3.26)**	**1.84 (1.35, 2.52)**
	Moroccan	**2.67 (1.93, 3.71)**	**1.60 (1.12, 2.29)**
	Surinamese	**3.27 (2.53, 4.23)**	**2.76 (2.09, 3.65)**
Maternal educational level[b]	**Ethnic background**	**Measuring time point**	
		Age 6 years	**Age 9 years**
		OR (95%CI)	**OR (95%CI)**
High	Dutch	1.00	1.00
	Turkish	**5.28 (2.47, 11.29)**	**5.17 (2.49, 10.74)**
	Moroccan	2.42 (0.97, 6.00)	**4.68 (2.20, 9.98)**
	Surinamese	**6.34 (3.71, 10.82)**	**5.83 (3.45, 9.83)**
Middle	Dutch	1.00	1.00
	Turkish	**2.49 (1.62, 3.81)**	1.61 (0.99, 2.62)
	Moroccan	**2.67 (1.55, 4.60)**	1.38 (0.77, 2.48)
	Surinamese	**2.78 (1.92, 4.03)**	**2.26 (1.54, 3.32)**
Low	Dutch	1.00	1.00
	Turkish	**1.89 (1.30, 2.75)**	1.09 (0.67, 1.77)
	Moroccan	**2.39 (1.50, 3.82)**	0.84 (0.48, 1.49)
	Surinamese	**2.47 (1.55, 3.94)**	1.58 (0.90, 2.78)

Table is based on imputed dataset. Bold print indicates statistical significance. Values represent odds ratios and 95% confidence intervals derived from multiple logistic regression analyses.
[a] Models were adjusted for child's exact age, maternal educational level and net household income
[b] Models were adjusted for child's exact age and net household income.

S3 Table. Associations of ethnic background with TV viewing time according to paternal educational level at each age (n=4,833)

Paternal educational level	Ethnic background	Measuring time point				
		Age 2 years	Age 3 years	Age 4 years	Age 6 years	Age 9 years
		OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
High	Dutch	1.00	1.00	1.00	1.00	1.00
	Turkish	**3.07 (1.35, 7.00)**	**2.43 (1.23, 4.82)**	**2.23 (1.21, 4.11)**	**2.68 (1.49, 4.82)**	**2.53 (1.03, 6.25)**
	Moroccan	3.19 (0.65, 15.60)	2.07 (0.49, 8.83)	2.99 (0.98, 9.12)	**2.91 (1.12, 7.55)**	1.22 (0.45, 3.29)
	Surinamese	**6.61 (3.20, 13.66)**	**4.02 (2.11, 7.68)**	**2.21 (1.22, 3.99)**	1.62 (0.90, 2.93)	**4.53 (1.59, 12.92)**
Middle	Dutch	1.00	1.00	1.00	1.00	1.00
	Turkish	1.26 (0.51, 3.09)	1.00 (0.43, 2.32)	1.38 (0.69, 2.74)	1.96 (1.00, 3.84)	2.21 (0.74, 6.60)
	Moroccan	1.20 (0.32, 4.41)	**5.18 (1.39, 19.28)**	1.72 (0.63, 4.67)	3.18 (0.89, 11.37)	2.31 (0.51, 10.56)
	Surinamese	2.05 (0.97, 4.36)	**4.02 (2.11, 7.68)**	1.67 (0.89, 3.14)	**2.20 (1.21, 4.01)**	**2.51 (1.03, 6.10)**
Low	Dutch	1.00	1.00	1.00	1.00	1.00
	Turkish	0.40 (0.15, 1.08)	0.88 (0.45, 1.72)	1.06 (0.59, 1.92)	0.70 (0.40, 1.21)	0.97 (0.38, 2.48)
	Moroccan	0.54 (0.15, 1.91)	1.09 (0.44, 2.74)	1.62 (0.71, 3.68)	1.45 (0.57, 3.69)	1.28 (0.36, 4.49)
	Surinamese	1.71 (0.74, 3.97)	0.59 (0.25, 1.39)	1.12 (0.56, 2.20)	1.42 (0.73, 2.75)	1.30 (0.52, 3.23)

Table is based on imputed dataset. Bold print indicates statistical significance. Values represent odds ratios and 95% confidence intervals derived from multiple logistic regression analyses.
Models were adjusted for child's exact age and net household income.

S4 Table. Parental attitude towards children's TV viewing time according to ethnic background (N=4,833)

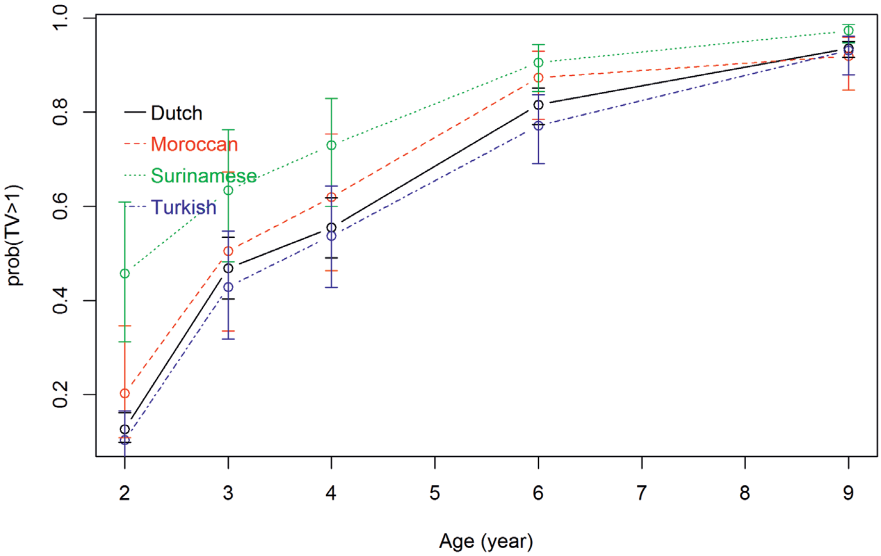
		Ethnic background				P-value[b]
		Dutch	Turkish	Moroccan	Surinamese	
TV set in child's bedroom[a]	Age 3 years	42 (1.8)	28 (11.2)	24 (16.6)	17 (9.1)	<0.001
	Age 6 years	330 (12.0)	122 (31.4)	77 (31.2)	88 (28.9)	<0.001
	Age 9 years	407 (17.6)	72 (33.0)	43 (26.2)	82 (36.0)	<0.001
Parents' TV viewing time (age 4 years)	A lot	248 (10.4)	37 (14.3)	27 (16.7)	34 (16.8)	0.003
	Neither a lot nor a little	1180 (49.7)	139 (53.7)	81 (50.0)	101 (50.0)	
	A little	947 (39.9)	83 (32.0)	54 (33.3)	67 (33.2)	

Table is based on non-imputed dataset.
[a] Values are percentages by different ethnic background.
[b] P-values are calculated by Chi-square test for categorical variables

S5 Table. Children's TV viewing time according to TV set in child's bedroom

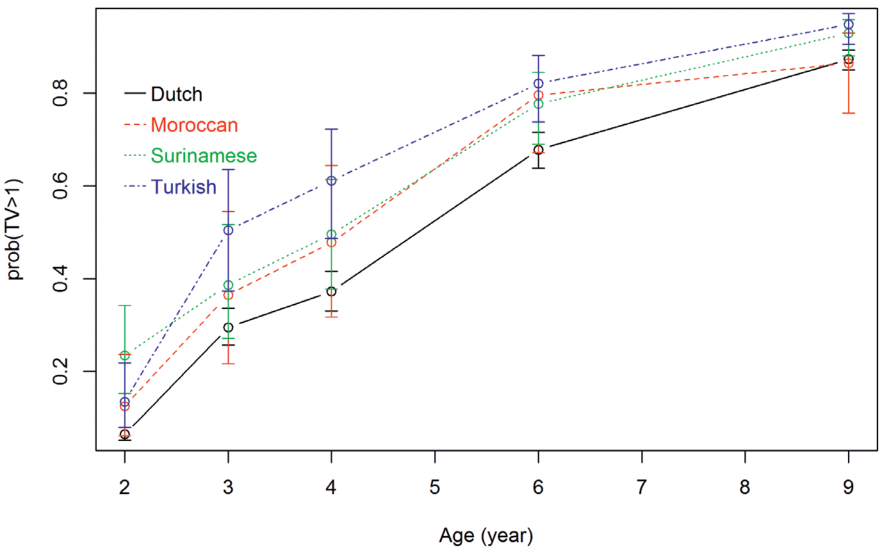
		TV viewing time		P-value[a]
		≥ 1 hour/day	< 1 hour/day	
TV set in child's bedroom	Age 3 years	70 (7.4)	38 (1.8)	<0.001
	Age 6 years	505 (21.4)	191 (11.0)	<0.001
	Age 9 years	598 (25.1)	99 (11.1)	<0.001

Table is based on non-imputed dataset.
[a] P-values are calculated by Chi-square test for categorical variables



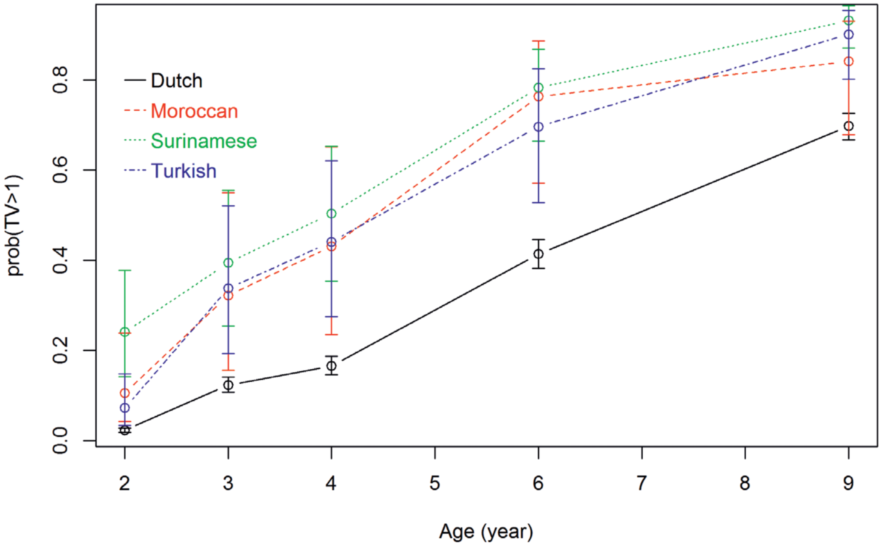
S1 Fig. Association between ethnic background and TV viewing time trajectories in children of low-educated mothers (confidence interval bars included)

Results are based on a generalized logistic mixed model and reflect the probability of TV viewing time of >1 hour/day (based on 2,579 measurements) in the first 9 years for children of mothers with low education level.



S2 Fig. Association between ethnic background and TV viewing time trajectories in children of middle-educated mothers (confidence interval bars included)

Results are based on a generalized logistic mixed model and reflect the probability of TV viewing time of >1 hour/day (based on 4,656 measurements) in the first 9 years for children of mothers with middle education level.



S3 Fig. Association between ethnic background and TV viewing time trajectories in children of high-educated mothers (confidence interval bars included)

Results are based on a generalized logistic mixed model and reflect the probability of TV viewing time of >1 hour/day (based on 9,276 measurements) in the first 9 years for children of mothers with high education level.

2 Social inequalities in child health outcomes

CHAPTER 5

Sociodemographic factors, current asthma and lung function in an urban child population

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Abstract

Background
We aimed to assess which sociodemographic factors are associated with current asthma and indicators of lung function in 10-year-old children.

Methods
We analysed data of 5237 children (Mean age: 9.7, SD: 0.3) from the Generation R Study (2012-2016), a population-based cohort study in the Netherlands. Indicators of sociodemographic factors included parental educational level, net household income, financial difficulties, parental employment status and child ethnic background. Current asthma (yes/no) was defined as ever doctor-diagnosed-asthma combined with wheezing symptoms or asthma-medication use in the past 12 months. Lung function was measured by spirometry and included forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), FEV_1/FVC, and forced expiratory flow after exhaling 75% of FVC (FEF_{75}). Within-study sex-, height- and age-adjusted lung function measurements' z-scores were converted.

Results
After adjustment for all sociodemographic factors, an independent association was observed between ethnic background with current asthma and lung function. Compared with children with a Dutch background, children with a nonwestern ethnic background had a higher odds of having current asthma (OR: 1.61, 95% CI: 1.02, 2.53), lower FVC z-score (−0.25, 95% CI: −0.35, −0.14), higher FEV_1/FVC z-score (0.26, 95% CI: 0.14, 0.37) and higher $FEF_{75\%}$ z-score (0.15, 95% CI: 0.04, 0.25).

Conclusions
Among 10-year-old children, ethnic background was associated with current asthma and lung function after adjusting for a wide range of sociodemographic factors. No associations were found between socioeconomic status indicators and current asthma. Explanations for these associations such as language barriers, suboptimal care or pathophysiological differences require further investigation.

Introduction

Asthma is one of the most common chronic diseases worldwide [1]. According to phase III (2000-2003) of the International Study of Asthma and Allergies in Childhood (ISAAC), the global prevalence rate of ever had asthma was 13.8% among 13-14-year old children, while the prevalence rate was even higher in western Europe, namely 16.3% [1]. Childhood asthma is related to school absenteeism, psychosocial problems, life threatening exacerbations, and impaired quality of life [2, 3]. Previous studies [4-6] suggested that having a low family socioeconomic status (SES) and an ethnic minority background is associated with asthma-related outcomes. Low family SES has been reported to be associated with more frequent emergency department visits [7], more frequent hospitalizations [8, 9], and higher mortality rates of asthma [10]. Studies from the United States and the United Kingdom found that children with an ethnic minority backgrounds have higher asthma-related hospitalizations rates and mortality rates than their peers [4, 11, 12].

However studies regarding the association between such sociodemographic factors and asthma-related outcomes have showed inconsistent results among children aged 9 and older [13]. A systematic review showed that the association between SES and asthma varied by the SES indicators used [14]. Low parental educational level was associated with higher levels of asthma [15]. Low family income was associated with lower level of asthma [16]. Furthermore, parental educational level and household income were most frequently used SES indicators [14]. Associations between other SES indicators (i.e. parental unemployment and financial difficulties) and asthma can offer a thorough view of socioeconomic inequalities in asthma and yet have not been addressed enough.

Furthermore, measurements of lung function are important for the evaluation of lung development and the presence of asthma but few studies assessed the association between sociodemographic factors and asthma-related outcomes as well as lung function measurements among children [17, 18]. Mostly children with a Caucasian, African American, South East Asian and North East Asian ethnic background have been studied with regard to lung function measurements. Based on these populations, the reference data for clinical inferences on lung function have been developed [19]. Ethnic minority groups that are common in western Europe, such as Moroccan, Surinamese and Turkish, are underrepresented in the literature [20]. No adequate reference data currently exist for the ethnic mix of our study population.

In the present study, we aimed to assess the associations between a wide range of sociodemographic factors (i.e. parental educational level, net household income, financial difficulties, parental employment status and ethnic background) with current asthma (ever doctor-diagnosed-asthma combined with wheezing symptoms or asthma-medication use in the past 12 months) among 10-year-old children. Secondly, we calculated within-study sex-, height- and age-adjusted lung function measurements' z-scores. We explored the associations between family SES, ethnic background and the lung function measurements' z-scores.

Materials and methods

Study design

This study was embedded in the Generation R Study, a population-based prospective cohort study from early fetal life onwards in Rotterdam, the Netherlands. A detailed description of the study design and participant inclusion procedure has been published previously [21]. Consent for postnatal follow-up was available for 7,393 children. Children with missing data on asthma or lung function (n=1,609), and on all sociodemographic factors (n=111) were excluded. To avoid clustering of data, second (n=427) and third children (n=9) of the same mother were excluded, leaving a study population of 5,237 participants. The study was conducted in accordance with the guidelines proposed in the Declaration of Helsinki. The Medical Ethics Committee of the Erasmus Medical Center, Rotterdam, approved the study. Written informed consent was obtained from all participants.

Sociodemographic factors

Sociodemographic factors included maternal and paternal educational level, net household income, financial difficulties, maternal and paternal employment status, and child ethnic background. Maternal and paternal educational level was obtained by questionnaire when the child was 6 years old and categorized as follows: low (no education, primary school, lower vocational training, intermediate general school, or three years or less general secondary school), mid-low (more than three years general secondary school, intermediate vocational training, or first year of higher vocational training), mid-high (higher vocational training), and high (university or PhD degree) [22]. Self-reported net household income (<€2000/month, €2000-€3200/month, >€3200/month) [23] and maternal and paternal employment status (no paid job, paid job) were obtained by questionnaire at child age 6 years. Financial difficulties (yes, no) were defined as difficulties in paying rent, electricity bills, food and suchlike during the past year, assessed by a questionnaire at child age 2 years. Child ethnic background (Dutch, other western, non-western) was based on the country of birth of the parents, which was assessed by questionnaires when the child was 6 years old. If one of the parents was born outside the Netherlands, this country of birth determined the ethnic background of the child. If both parents were born outside the Netherlands, the country of birth of the mother determined the ethnic background [24].

Current asthma and lung function

Current asthma at the age of 10 years (yes or no) was defined as ever diagnosis of asthma (yes or no), with either wheezing (yes or no) or medication use (yes or no) in the past

12 months. Information on whether the child ever received a diagnosis of asthma and whether the child suffered from wheezing in the past 12 months was obtained by questionnaire using adapted items of the ISAAC core questionnaires [25]. Information on asthma-related medication use in the past 12 months was obtained during the child's visit at the research center at age 10 years. During the visit, lung function was measured by spirometry according to the American Thoracic Society and European Respiratory Society guidelines [26], and included Forced Expiratory Volume in the first second (FEV_1) , Forced Vital Capacity (FVC), FEV_1/FVC, and Forced Expiratory Flow after exhaling 75% of FVC (FEF_{75}). Lung function measurements were converted into study specific sex-, height- and age-adjusted z-scores using multiple regression analysis. The general form of the equation was: $Y = a + b * height + c * age$ for boys and girls separately. Each value of lung function measurement, height or age was log transformed. The goodness of fit was judged from inspection of normal Q-Q plots.

Statistical analyses

The associations between sociodemographic factors and current asthma were assessed by logistic regression models adjusting for confounders: maternal age, marital status, parity, child gender and exact age at measurement. The associations between sociodemographic factors and lung function measurements were assessed by linear regression models adjusting for maternal age, marital status and parity. The first set of models included each indicator of sociodemographic factors separately, adjusted with confounders (i.e. basic models). The second set of models included all indicators of sociodemographic factors (i.e. full models) to assess the independent effects of each sociodemographic factor. Interaction effects between ethnic background and each SES indicator were assessed with UNIANOVA (see Appendix Table A1). Bonferroni correction was applied for multiple testing (P=0.10/30=0.003) [27]. Collinearity analysis using linear regression yielded acceptable collinearity (VIF<3) between SES indicators; therefore, these variables were included simultaneously in the full models. Effect estimates (ORs and z-score difference) and their 95% confidence intervals (CIs) were reported. Statistical analyses were performed using IBM SPSS statistics for Windows, version 24.0. Armonk, NY: IBM Corp.

Nonresponse analyses

Sociodemographic factors of children with missing data on current asthma and lung function measurements (n=1,609) were compared with those of children without missing data (n=5,237) using Chi-square tests. Data were more often missing for children from parents with a low maternal or paternal educational level, a low household income, a family with financial difficulties, a mother or father without a paid job, or from non-western ethnic background (all $p < 0.05$).

Sensitivity analyses

Sensitivity analyses were performed using specific groups of non-western population (i.e. Moroccan, Turkish and Surinamese and other non-western) in the full model to explore the associations between ethnic background and asthma-related outcomes (see Appendix Table A2). Also, we explored the associations between each SES indicator separately and asthma-related outcomes adjusting for ethnic background (see Appendix Table A3). Possible residual confounding was explored by additionally adjusted for a wide range of other potential confounders (i.e. child's birth weight, gestational age, ever eczema at age 9 years, respiratory tract infections, maternal age at enrollment, marital status, parity, maternal smoking during pregnancy, ever breastfeeding, pets exposure at home, daycare attendance and maternal BMI before pregnancy) in the full model (see Appendix Table A4). Stratified analyses were performed in the association between ethnic background and lung function with or without current asthma (see Appendix Table A5 and A6).

Results

Participant characteristics

Table 1 summarizes the characteristics of the participants stratified by current asthma (5.9%) or no current asthma (94.1%) at age 10 years (mean: 9.7, SD: 0.3). Children with current asthma were more likely to have a mother with low educational level, and belong to a household with a net income of less than €2000/month (both $p<0.05$) . Compared with children without current asthma, children with current asthma more often were male, with a non-western ethnic background, had a lower FEV_1, lower FEV_1/FVC and lower $FEF_{75\%}$ ($P<0.05$).

Table 1. Characteristics of children and their mothers (N=5,237)

	Total	Current Asthma	No current asthma	P-value*
	N=5,237	N=259 (5.9)	N=4,161 (94.1)	
Parental characteristics				
Maternal education				
Low	395 (9.8)	34 (15.2)	361 (9.5)	0.02
Mid-low	1183 (29.4)	71 (31.7)	1112 (29.2)	
Mid-high	1167 (29.0)	56 (25.0)	1111 (29.2)	
High	1281 (31.8)	63 (28.1)	1218 (32.0)	
Paternal education				
Low	506 (13.7)	40 (20.1)	466 (13.3)	0.06
Mid-low	961 (26.0)	46 (23.1)	915 (26.2)	
Mid-high	891 (24.1)	44 (22.1)	847 (24.2)	
High	1340 (36.2)	69 (34.7)	1271 (36.3)	

Table 1. Continued.

	Total N=5,237	Current Asthma N=259 (5.9)	No current asthma N=4,161 (94.1)	P-value*
Net household income				
Less than €2000/month	738 (19.3)	55 (25.9)	683 (18.9)	0.01
€2000/month-€3200/month	1002 (26.2)	63 (29.7)	939 (26.0)	
More than €3200/month	2088 (54.5)	94 (44.3)	1994 (55.1)	
Financial difficulties (Yes)	612 (18.5)	41 (23.4)	571 (18.2)	0.09
Maternal unemployment	802 (20.9)	47 (22.5)	755 (20.8)	0.57
Paternal unemployment	176 (4.9)	12 (6.6)	164 (4.8)	0.28
Children's characteristics				
Child ethnic background				
Dutch	2826 (64.1)	141 (54.4)	2685 (64.7)	<0.001
Other western	387 (8.8)	14 (5.4)	373 (9.0)	
Non-western	1197 (27.1)	104 (40.2)	1093 (26.3)	
Female sex	2216 (50.1)	95 (36.7)	2121 (51.0)	<0.001
FEV_1, mean (SD), L	2.01 (0.29)	1.97 (0.30)	2.01 (0.29)	0.05
FEV_1 z-score, mean (SD)	0.03 (0.97)	-0.14 (1.04)	0.04 (0.97)	0.02
FVC, mean (SD), L	2.33 (0.36)	2.36 (0.36)	2.33 (0.36)	0.14
FVC z-score, mean (SD)	0.02 (0.97)	0.14 (1.08)	0.02 (0.97)	0.11
FEV_1/FVC, mean (SD), %	86.70 (5.71)	83.90 (6.65)	86.87 (5.60)	<0.001
FEV_1/FVC z-score, mean (SD)	0.01 (0.98)	-0.43 (1.16)	0.04 (0.97)	<0.001
FEF_{75}, mean (SD), L/s	1.14 (0.34)	1.02 (0.34)	1.15 (0.34)	<0.001
FEF_{75} z-score, mean (SD)	0.02 (0.98)	-0.34 (0.95)	0.04 (0.98)	<0.001

* Chi-square tests were used for categorical variables and independent T tests were used for continuous variables.

Sociodemographic factors and current asthma

Children of low educated mothers (OR: 1.81, 95% CI: 1.13, 2.91) had higher odds of having current asthma compared with children of high educated mothers (Basic models, Table 2). Children from low income households (OR: 1.71, 95% CI: 1.15, 2.54) and middle income households (OR: 1.43, 95% CI: 1.01, 2.03) had higher odds of having current asthma compared with children living in high income households. Children with a non-western ethnic background (OR: 1.64, 95% CI: 1.22, 2.20) had higher odds of having current asthma compared with children with a Dutch background.

After adjustment for all indicators in the model, an independent association was observed between ethnic background and current asthma only (Full models, Table 3). Children with a non-western ethnic background (OR: 1.61, 95% CI: 1.02, 2.53) had a higher odds of having current asthma compared with children with a Dutch background.

Sociodemographic factors and lung function

When compared with high paternal educational level, low paternal educational level was associated with lower FEV_1 (z-score difference: -0.11, 95% CI: -0.21, -0.01) and lower FVC (z-score difference: -0.16, 95% CI: -0.26, -0.06) (Basic models, Table 2). Compared with children from a household income more than €3200/month, low household income (less than €2000/month) was associated with lower FVC (z-score difference: -0.14, 95% CI: -0.24, -0.05). Financial difficulties were associated with higher FEV_1/FVC (z-score difference: 0.12, 95% CI: 0.03, 0.21) and higher FEF_{75} (z-score difference: 0.10, 95%CI: 0.01, 0.19). Maternal unemployment was associated with higher FVC (z-score difference: 0.08, 95%CI: 0.01, 0.16). Table 2 shows differences between ethnic subgroups and lung function measurements. Compared to children with a Dutch background, a non-western ethnic background was associated with lower FEV_1 (z-score difference: -0.18, 95% CI: -0.25, -0.11) and lower FVC (z-score difference: -0.28, 95% CI: -0.35, -0.21). The difference in FVC exceeded that of FEV_1, so that FEV_1/FVC was higher in children with a non-western ethnic background (z-score difference: 0.18, 95% CI: 0.11, 0.25).

After adjustment for all sociodemographic factors in the model, independent associations were observed for ethnic background with lung function measurements (Full models, Table 3). Compared with children with a Dutch background, a non-western ethnic background was associated with lower FVC (z-score difference: -0.25, 95% CI: -0.35, -0.14), higher FEV_1/FVC (z-score difference: 0.26, 95% CI: 0.14, 0.37) and higher FEF_{75} (z-score difference: 0.15, 95% CI: 0.04, 0.25). Also, maternal unemployment was associated with higher FVC (z-score difference: 0.14, 95% CI: 0.03, 0.25). Children from a family with financial difficulties were more likely to have higher FEV_1/FVC (z-score difference: 0.12, 95% CI: 0.01, 0.24).

Table 2. Associations of sociodemographic factors with current asthma and lung function at 10 years of age (basic models).

	OR (95% CI)	z-score difference (95% CI)			
	Current asthma* n=4,420	FEV_1† n=4,641	FVC† n=4,641	FEV_1/FVC† n=4,641	FEF_{75}† n=4,641
Maternal educational level					
High	Reference	Reference	Reference	Reference	Reference
Mid-high	0.94 (0.64, 1.38)	-0.03 (-0.11, 0.05)	0.001 (-0.08, 0.08)	-0.05 (-0.13, 0.03)	-0.02 (-0.10, 0.06)
Mid-low	1.19 (0.81, 1.74)	-0.06 (-0.14, 0.02)	-0.07 (-0.16, 0.01)	0.02 (-0.07, 0.10)	0.05 (-0.04, 0.13)
Low	**1.81 (1.13, 2.91)**	0.02 (-0.09, 0.13)	-0.02 (-0.13, 0.09)	0.08 (-0.03, 0.20)	0.10 (-0.01, 0.22)
Paternal educational level					
High	Reference	Reference	Reference	Reference	Reference
Mid-high	0.86 (0.57, 1.30)	-0.04 (-0.12, 0.05)	-0.04 (-0.13, 0.04)	0.01 (-0.08, 0.09)	0.03 (-0.06, 0.11)
Mid-low	0.89 (0.59, 1.33)	-0.04 (-0.12, 0.04)	**-0.09 (-0.17, -0.003)**	0.07 (-0.01, 0.16)	0.07 (-0.02, 0.15)
Low	1.27 (0.81, 2.00)	**-0.11 (-0.21, -0.01)**	**-0.16 (-0.26, -0.06)**	0.08 (-0.03, 0.18)	0.05 (-0.06, 0.15)
Net household income					
More than €3200/month	Reference	Reference	Reference	Reference	Reference
€2000-€3200/month	**1.43 (1.01, 2.03)**	-0.001 (-0.08, 0.08)	-0.04 (-0.11, 0.04)	0.06 (-0.02, 0.13)	0.05 (-0.03, 0.12)
Less than €2000/month	**1.71 (1.15, 2.54)**	-0.09 (-0.19, 0.01)	**-0.14 (-0.24, -0.05)**	0.08 (-0.02, 0.18)	0.05 (-0.05, 0.15)
Financial difficulties					
No	Reference	Reference	Reference	Reference	Reference
Yes	1.27 (0.86, 1.87)	0.06 (-0.03, 0.16)	-0.04 (-0.10, 0.09)	**0.12 (0.03, 0.21)**	**0.10 (0.01, 0.19)**
Paternal unemployment					
Paid job	Reference	Reference	Reference	Reference	Reference
No paid job	1.33 (0.70, 2.51)	-0.04 (-0.18, 0.10)	-0.02 (-0.16, 0.12)	-0.03 (-0.17, 0.11)	-0.04 (-0.18, 0.10)
Maternal unemployment					
Paid job	Reference	Reference	Reference	Reference	Reference
No paid job	1.07 (0.75, 1.52)	0.06 (-0.01, 0.14)	**0.08 (0.01, 0.16)**	-0.04 (-0.11, 0.04)	-0.01 (-0.08, 0.07)

Table 2. Continued.

	OR (95% CI)	z-score difference (95% CI)			
	Current asthma* n=4,420	FEV_1† n=4,641	FVC† n=4,641	FEV_1/FVC† n=4,641	FEF_{75}† n=4,641
Ethnic background$					
Dutch	Reference	Reference	Reference	Reference	Reference
Other western	0.72 (0.40, 1.28)	**0.13 (0.02, 0.23)**	**0.11 (0.002, 0.22)**	0.04 (-0.06, 0.15)	0.08 (-0.03, 0.19)
Non-western	**1.64 (1.22, 2.20)**	**-0.18 (-0.25, -0.11)**	**-0.28 (-0.35, -0.21)**	**0.18 (0.11, 0.25)**	0.05 (-0.03, 0.12)

Bold print indicates statistical significance. Each sociodemographic factor was added to the model separately.
* Models were adjusted for maternal age at enrollment, marital status, parity, child's gender and exact age at measurement.
† Models were adjusted for maternal age at enrollment, marital status and parity.
$ Other western: Oceanian, European, American, and Japanese. Non-western: Antillean, Cape Verdean, Moroccan, Surinamese, Turkish, Kurdish and others.

Table 3. Associations of sociodemographic factors with current asthma and lung function at 10 years of age (full models*).

	OR (95% CI)	z-score difference (95% CI)			
	Current asthma* n=4,420	FEV_1† n=4,641	FVC† n=4,641	FEV_1/FVC† n=4,641	FEF_{75}† n=4,641
Maternal educational level					
High	Reference	Reference	Reference	Reference	Reference
Mid-high	0.95 (0.59, 1.53)	0.00 (-0.10, 0.10)	0.04 (-0.06, 0.14)	-0.06 (-0.16, 0.04)	-0.02 (-0.12, 0.08)
Mid-low	1.18 (0.69, 2.04)	-0.02 (-0.14, 0.09)	0.02 (-0.09, 0.14)	-0.09 (-0.21, 0.03)	-0.001 (-0.12, 0.12)
Low	1.25 (0.53, 2.96)	0.16 (-0.04, 0.36)	0.14 (-0.06, 0.35)	-0.02 (-0.23, 0.19)	0.11 (-0.09, 0.31)
Paternal educational level					
High	Reference	Reference	Reference	Reference	Reference
Mid-high	0.65 (0.39, 1.08)	-0.03 (-0.13, 0.07)	-0.05 (-0.15, 0.05)	0.03 (-0.07, 0.13)	0.05 (-0.05, 0.15)
Mid-low	0.61 (0.35, 1.07)	-0.05 (-0.16, 0.06)	-0.08 (-0.19, 0.03)	0.01 (-0.11, 0.13)	0.03 (-0.08, 0.14)
Low	1.07 (0.55, 2.08)	-0.03 (-0.18, 0.13)	-0.04 (-0.20, 0.12)	0.03 (-0.13, 0.20)	0.01 (-0.15, 0.17)

Table 3. Continued.

	OR (95% CI)	z-score difference (95% CI)			
	Current asthma* n=4,420	FEV_1† n=4,641	FVC† n=4,641	FEV_1/FVC† n=4,641	FEF_{75}† n=4,641
Net household income					
More than €3200/month	Reference	Reference	Reference	Reference	Reference
€2000-€3200/month	1.17 (0.72, 1.91)	0.01 (-0.09, 0.11)	-0.01 (-0.11, 0.09)	0.04 (-0.06, 0.15)	0.01 (-0.10, 0.11)
Less than €2000/month	1.43 (0.66, 3.09)	-0.12 (-0.30, 0.05)	-0.16 (-0.34, 0.02)	0.09 (-0.10, 0.28)	0.01 (-0.17, 0.19)
Financial difficulties					
No	Reference	Reference	Reference	Reference	Reference
Yes	0.89 (0.53, 1.50)	0.08 (-0.03, 0.19)	0.02 (-0.09, 0.13)	**0.12 (0.01, 0.24)**	0.08 (-0.04, 0.19)
Paternal unemployment					
Paid job	Reference	Reference	Reference	Reference	Reference
No paid job	0.50 (0.17, 1.46)	-0.08 (-0.27, 0.12)	-0.01 (-0.20, 0.19)	-0.11 (-0.31, 0.09)	-0.14 (-0.33, 0.06)
Maternal unemployment					
Paid job	Reference	Reference	Reference	Reference	Reference
No paid job	0.88 (0.52, 1.47)	0.08 (-0.03, 0.19)	**0.14 (0.03, 0.25)**	-0.09 (-0.20, 0.02)	-0.06 (-0.17, 0.05)
Ethnic background$					
Dutch	Reference	Reference	Reference	Reference	Reference
Other western	0.94 (0.48, 1.86)	0.13 (-0.01, 0.26)	0.12 (-0.01, 0.26)	0.01 (-0.12, 0.15)	0.09 (-0.04, 0.23)
Non-western	**1.61 (1.02, 2.53)**	-0.10 (-0.20, 0.01)	**-0.25 (-0.35, -0.14)**	**0.26 (0.14 0.37)**	**0.15 (0.04, 0.25)**

Bold print indicates statistical significance.
All sociodemographic factors were added to the model.
* Models were adjusted for maternal age at enrollment, marital status, parity, child's gender and exact age at measurement.
† Models were adjusted for maternal age at enrollment, marital status and parity.
$ Other western: Oceanian, European, American, and Japanese. Non-western: Antillean, Cape Verdean, Moroccan, Surinamese, Turkish, Kurdish and others.

Interaction effects

Apart from an interaction effect between ethnic background and maternal unemployment, no statistically significant interaction effects were found. All P-values of the interaction effect analyses are presented in Appendix Table A1.

Sensitivity analyses

Appendix Table A2 shows that children with a Surinamese ethnic background had higher odds (OR: 2.52, 95% CI: 1.29, 4.90) of having current asthma compared with children with a Dutch background. Results from Appendix Table A3 are comparable to the main analyses, although effect estimates (z-score difference) were larger. No significant association was found between ethnic background and current asthma after adjusting for extra potential confounders (Appendix Table A4). Stratified analyses showed that among children without current asthma, results were comparable to the main analyses (Appendix Table A5). Among children with current asthma, no association was found between ethnic background and lung function (Appendix Table A6).

Discussion

This study contributes to the knowledge regarding sociodemographic risk factors for asthma-related outcomes in a sample of European children with diverse ethnic background. After adjustment for all sociodemographic factors, maternal unemployment was associated with higher FVC and financial difficulties with higher FEV_1/FVC. Children with a non-western ethnic background were significantly more likely to have current asthma, lower FVC, higher FEV_1/FVC and higher FEF_{75}.

With regard to asthma, a systematic review reported that among children aged 9 and younger, lower family SES, including lower parent occupation, and higher poverty status, are associated with asthma [13]. However, among children aged 9 years and older, these associations were not apparent [13]. Our study supports this finding, as we also did not observe an inverse association between family SES and asthma at school-age after correcting for other sociodemographic factors including a wide range of family SES indicators. A possible explanation might be that when children grow older, they tend to spend more time at school or outside with their friends instead of staying at home. Thus, the impact of poor housing conditions, which children from low SES families tend to be exposed to, may be larger in early childhood than at later age [13, 28].

Our findings regarding differences in asthma prevalence according to ethnic background correspond to earlier studies showing higher risk of asthma among preschool children, school-aged children, and adolescents from ethnic minority groups [4, 29, 30]. Our study adds to the evidence on association between ethnic background and asthma by showing such differences remain after adjustment for a wide range of family SES indicators at 10-years of age. The higher risk of asthma among non-western children is not fully explained by low income or low educational level. Previous studies showed that differences in asthma between subgroups with different ethnic backgrounds were independent of indicators of SES, and could only partly be explained by bad housing (e.g. houses infested with rodents, lacking sufficient heat) and neighborhood conditions (e.g. little/no social cohesion, boarded-up buildings nearby) [31]. In our study, when we evaluated the non-western population and added them to the full model as specific groups, only children with a Surinamese ethnic background had higher odds of having current asthma compared to children with Dutch background (Appendix Table A.2). Interpretation of these results should be done with caution because of a lack of statistical power. Future studies on differences in asthma among ethnic subgroups are needed to also provide insight in language barriers in care, suboptimal care, or pathophysiological differences, especially in western Europe.

Children with a non-western ethnic background had lower FEV_1 and FVC than their Dutch peers. These findings are in line with previous studies reporting differences in lung function between subgroups with different ethnic backgrounds in age groups varying from the preschool period until adolescence [19, 32]. A study in United Kingdom showed that Black African/Caribbean and South Asian children were found to have lower FEV_1 and FVC than white children [32]. Another study in the United States have reported that African American children were taller but had lower FEV_1 and FVC than white children [18]. In our study, the relatively low in FEV_1 and FVC in children with a non-western ethnic background did not seem to reflect on airway obstruction, as their FEV_1/FVC ratios and end-expiratory flows were not low, but were slightly higher. This may be due to reduced lung and airway size rather than obstruction. However, such smaller airways may represent a risk factor for asthma symptoms in children [33], which provides a possible explanation of differences in asthma between subgroups with different ethnic backgrounds. Another explanation could be the difference in developmental age of puberty between populations [34, 35]. In childhood, FVC outgrows FEV_1, leading to falls in FEV_1/FVC; these trends are reversed in adolescence. FEV_1/FVC ratios are higher in the children shorter for their age [35]. Furthermore, stratified analyses showed that no association was found between ethnic background and lung function among children with current asthma. One possible explanation could be that medication was used to relieve the symptoms and thus improve the lung function among children with current asthma. Cautious interpretation of these results is needed because of the small sample size in the subgroup. We suggest that clinical practitioners pay attention to potential differential development of lung function among children with a migration background.

Independent association was observed for maternal unemployment with higher FVC after adjustment for all sociodemographic factors. This was an unexpected finding and not consistent with results of other lung function measurements. Further research is warranted to confirm the association between maternal employment status and child lung function.

Methodological considerations

A strength of this diverse urban-population-based study is the large number of subjects being studied with detailed and prospectively measured information on a wide range of indicators of family SES and specific lung function measurements.

Some limitations of the study have to be considered in the interpretation of the results. Child's ethnic background was defined according to the standard methods used in the Netherlands [24]. This definition implies that third generation immigrants were labelled as Dutch and were hence not distinguished. This may lead to reduction in the contrast between Dutch and other ethnic backgrounds, and the effect sizes then would be relatively smaller. Information on ever diagnosis of asthma and wheezing in the past 12 months was obtained by parental report using the questions from the ISAAC, a validated instrument in epidemiologic studies [36]. However, misclassification attributable to low parental awareness might be present.

Table 3 showed the associations between sociodemographic background and five asthma-related outcomes. However, with seven SES indicators together in each of the five models, there may be concerns for overlap between these factors. Although there appeared to be no multicollinearity (see method section), we performed sensitivity analyses to explore the associations between each SES indicator separately with asthma-related outcomes adjusting ethnic background in the models. Similar results were found for the associations between SES indicators and asthma-related outcomes (Appendix Table A.3). Apart from maternal unemployment, no associations were found between SES indicators and asthma-related outcomes after adjusting for ethnic background.

Another related argument concerns the possible residual confounding when assessing sociodemographic factors with asthma and lung function measurements. When we additionally adjusted for a wide range of other potential confounders, no significant association was found between ethnic background and current asthma (Appendix Table A.4). The associations between ethnic background and FVC and FEV_1/FVC remained. However, these additional variables in the model may also be considered as mediators, explaining the associations between sociodemographic factors and asthma [37, 38]. Therefore, they were excluded in the main analyses. Future studies should explore specific pathways related to the differences in asthma-related outcomes between subgroups with different ethnic backgrounds.

Conclusions

This study showed that after adjusting for a wide range of sociodemographic factors, children with a non-western ethnic background were more likely to have higher risk of current asthma, smaller lung volumes (FVC), but higher FEV_1/FVC and mid-expiratory flows (FEF_{75}) than children with a majority ethnic background. No associations were found between SES indicators and current asthma. Explanations for these associations such as language barriers, suboptimal care, or pathophysiological differences require further investigation in longitudinal studies. In the meantime, physicians, nurses and other health care professionals should be aware of the relatively high prevalence of asthma among children with a migration background in European cities.

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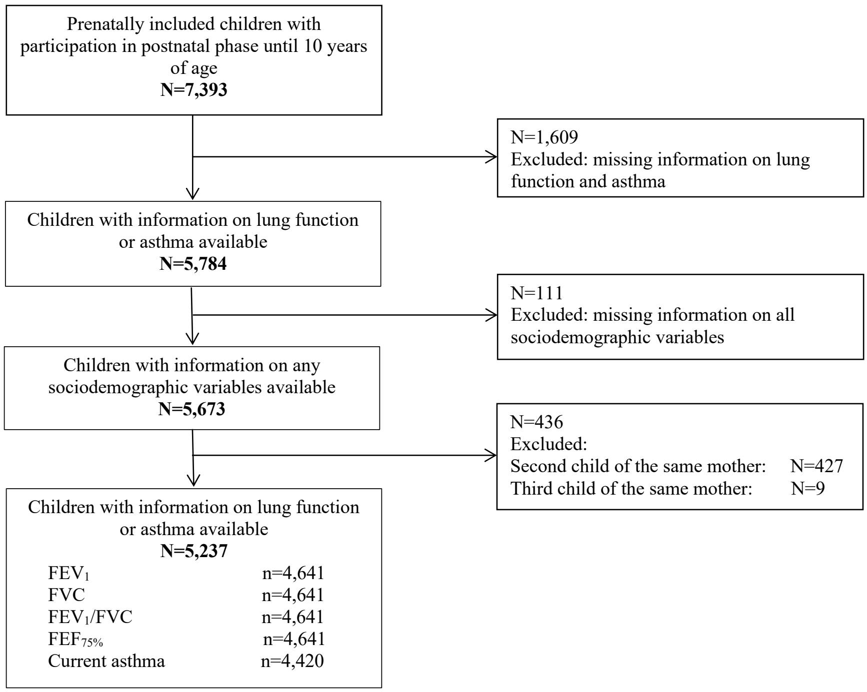

Supplementary material. Flowchart of participants included for analysis

Table A1. P-values for interaction effects between ethnic background and each socioeconomic status variables on current asthma and lung function measurement

Items	Current asthma	FEV_1	FVC	FEV_1/FVC	FEF_{75}
	P-value	P-value	P-value	P-value	P-value
Ethnic background*maternal educational level	0.980	0.120	0.066	0.626	0.903
Ethnic background*paternal educational level	0.924	0.085	0.091	0.572	0.410
Ethnic background*net household income	0.596	0.471	0.514	0.089	0.553
Ethnic background*financial difficulties	0.783	0.354	0.186	0.762	0.899
Ethnic background*paternal unemployment	0.958	0.483	0.920	0.332	0.492
Ethnic background*maternal unemployment	0.905	0.011	**0.002**	0.456	0.515

Significant P-values in bold
After applying Bonferroni correction for multiple testing (P=0.10/30=0.003), except interaction effect between ethnic background and maternal unemployment, no statistically significant interaction effect was found.

Table A2. Associations of sociodemographic factors with current asthma and lung function at 10 years of age (full models).

	OR (95% CI)	z Score change (95% CI)			
	Current asthma* n=4,420	FEV_1† n=4,641	FVC† n=4,641	FEV_1/FVC† n=4,641	FEF_{75}† n=4,641
Maternal educational level					
High	Reference	Reference	Reference	Reference	Reference
Mid-high	1.31 (0.55, 3.13)	0.01 (-0.09, 0.11)	0.05 (-0.05, 0.14)	-0.06 (-0.15, 0.04)	-0.02 (-0.11, 0.08)
Mid-low	1.14 (0.66, 1.98)	-0.01 (-0.12, 0.11)	0.04 (-0.08, 0.16)	-0.07 (-0.19, 0.04)	0.01 (-0.11, 0.12)
Low	1.31 (0.55, 3.13)	0.13 (-0.06, 0.33)	0.12 (-0.08, 0.31)	0.05 (-0.15, 0.25)	0.10 (-0.10, 0.30)
Paternal educational level					
High	Reference	Reference	Reference	Reference	Reference
Mid-high	0.65 (0.39, 1.05)	-0.03 (-0.13, 0.07)	-0.05 (-0.15, 0.05)	0.03 (-0.07, 0.15)	0.05 (-0.05, 0.15)
Mid-low	0.60 (0.34, 1.05)	-0.04 (-0.15, 0.07)	-0.07 (-0.18, 0.04)	0.04 (-0.08, 0.15)	0.04 (-0.08, 0.15)
Low	1.05 (0.54, 2.07)	-0.02 (-0.18, 0.14)	-0.03 (-0.19, 0.13)	0.03 (-0.13, 0.19)	0.01 (-0.15, 0.17)
Net household income					
More than €3200/month	Reference	Reference	Reference	Reference	Reference
€2000-€3200/month	1.20 (0.74, 1.96)	-0.004 (-0.11, 0.10)	-0.03 (-0.13, 0.08)	0.04 (-0.07, 0.14)	-0.001 (-0.10, 0.10)
Less than €2000/month	1.52 (0.69, 3.34)	**-0.18 (-0.35, -0.003)**	**-0.22 (-0.40, -0.04)**	0.05 (-0.13, 0.23)	-0.01 (-0.19, 0.17)
Financial difficulties					
No	Reference	Reference	Reference	Reference	Reference
Yes	0.90 (0.53, 1.51)	0.09 (-0.02, 0.19)	0.02 (-0.09, 0.13)	0.11 (0.00, 0.22)	
Paternal unemployment					0.07 (-0.04, 0.19)
Paid job	Reference	Reference	Reference	Reference	Reference
No paid job	0.48 (0.16, 1.39)	0.07 (-0.01, 0.15)	0.01 (-0.07, 0.09)	0.10 (0.02, 0.18)	0.14 (0.06, 0.22)

Table A2. Continued.

	OR (95% CI)	z Score change (95% CI)			
	Current asthma*	FEV_1 †	FVC†	FEV_1/FVC†	FEF_{75} †
	n=4,420	n=4,641	n=4,641	n=4,641	n=4,641
Maternal unemployment					
Paid job	Reference	Reference	Reference	Reference	Reference
No paid job	0.94 (0.56, 1.59)	0.03 (-0.08, 0.14)	0.09 (-0.02, 0.20)	-0.10 (-0.21, 0.01)	-0.08 (-0.19, 0.03)
Ethnic background					
Dutch (n=3134)	Reference	Reference	Reference	Reference	Reference
Other western (n=446)	0.93 (0.47, 1.84)	**0.13 (0.001, 0.26)**	0.13 (-0.003, 0.26)	0.02 (-0.11, 0.16)	0.10 (-0.04, 0.23)
Moroccan (n=267)	1.74 (0.67, 4.55)	0.07 (-0.17, 0.32)	-0.06 (-0.31, 0.18)	0.23 (-0.02, 0.48)	0.16 (-0.09, 0.41)
Turkish (n=328)	0.44 (0.10, 1.91)	**0.32 (0.12, 0.53)**	0.20 (-0.01, 0.41)	**0.23 (0.02, 0.44)**	**0.37 (0.16, 0.58)**
Surinamese (n=367)	**2.52 (1.29, 4.90)**	**-0.57 (-0.75, -0.39)**	**-0.71 (-0.89, -0.52)**	**0.23 (0.04, 0.41)**	-0.04 (-0.23, 0.14)
Other non-western (n=678)	1.53 (0.84, 2.78)	-0.03 (-0.17, 0.11)	**-0.20 (-0.35, -0.06)**	**0.29 (0.15, 0.44)**	**0.16 (0.02, 0.31)**

Bold print indicates statistical significance.
All sociodemographic factors were added to the model.
* Models were adjusted for maternal age at enrollment, marital status, parity, child's gender and exact age at measurement.
† Models were adjusted for maternal age at enrollment, marital status and parity.

Table A3. Associations of socioeconomic status with asthma and lung function at 10 years of age

	OR (95% CI)	z Score change (95% CI)			
	Current asthma	FEV_1	FVC	FEV_1/FVC	FEF_{75}
	n=4,420	n=4,641	n=4,641	n=4,641	n=4,641
Maternal educational level					
High	Reference	Reference	Reference	Reference	Reference
Mid-high	0.88 (0.60, 1.28)	-0.01 (-0.09, 0.07)	0.03 (-0.05, 0.11)	-0.06 (-0.14, 0.02)	-0.02 (-0.10, 0.06)
Mid-low	1.00 (0.68, 1.46)	-0.02 (-0.10, 0.07)	-0.01 (-0.09, 0.07)	-0.01 (-0.10, 0.07)	0.05 (-0.04, 0.13)
Low	1.34 (0.83, 2.17)	0.11 (-0.01, 0.22)	0.10 (-0.01, 0.22)	0.02 (-0.10, 0.13)	0.10 (-0.02, 0.21)
Paternal educational level					
High	Reference	Reference	Reference	Reference	Reference
Mid-high	0.83 (0.55, 1.26)	-0.03 (-0.11, 0.06)	-0.02 (-0.11, 0.06)	-0.002 (-0.09, 0.08)	0.02 (-0.06, 0.11)
Mid-low	0.82 (0.55, 1.24)	-0.02 (-0.11, 0.06)	-0.05 (-0.14, 0.03)	0.05 (-0.04, 0.13)	0.06 (-0.03, 0.14)
Low	1.06 (0.67, 1.70)	-0.06 (-0.17, 0.04)	-0.08 (-0.18, 0.03)	0.02 (-0.09, 0.12)	0.03 (-0.08, 0.13)
Net household income					
More than €3200/month	Reference	Reference	Reference	Reference	Reference
€2000-€3200/month	1.31 (0.92, 1.85)	0.03 (-0.05, 0.11)	0.02 (-0.06, 0.09)	0.02 (-0.05, 0.10)	0.04 (-0.04, 0.12)
Less than €2000/month	1.27 (0.79, 2.03)	-0.004 (-0.11, 0.10)	-0.003 (-0.11, 0.10)	-0.01 (-0.11, 0.10)	0.02 (-0.09, 0.13)
Financial difficulties (Yes)	1.19 (0.80, 1.78)	0.09 (-0.001, 0.19)	0.05 (-0.05, 0.14)	0.08 (-0.01, 0.17)	0.09 (-0.01, 0.18)
Paternal unemployment	1.09 (0.58, 2.04)	0.000 (-0.14, 0.14)	0.07 (-0.08, 0.21)	-0.10 (-0.24, 0.04)	-0.08 (-0.22, 0.07)
Maternal unemployment	0.95 (0.66, 1.35)	**0.09 (0.02, 0.17)**	**0.14 (0.06, 0.21)**	-0.07 (-0.15, 0.01)	-0.01 (-0.09, 0.06)

Bold print indicates statistical significance.
* Each socioeconomic status indicator was in the model separately.
Models were adjusted for child's ethnic background, gender, exact age at measurement, maternal age at enrollment, marital status and parity.

Table A4. Associations of sociodemographic factors with asthma and lung function at 10 years of age (adjustment with additional confounders[*]).

	OR (95% CI)	z Score change (95% CI)			
	Current asthma n=4,420	FEV_1 n=4,641	FVC n=4,641	FEV_1/FVC n=4,641	FEF_{75} n=4,641
Maternal educational level					
High	Reference	Reference	Reference	Reference	Reference
Mid-high	0.70 (0.35, 1.41)	0.02 (-0.11, 0.15)	0.02 (-0.11, 0.16)	0.004 (-0.13, 0.14)	0.07 (-0.07, 0.20)
Mid-low	0.98 (0.40, 2.42)	-0.01 (-0.18, 0.16)	0.03 (-0.15, 0.20)	-0.07 (-0.24, 0.11)	0.06 (-0.12, 0.24)
Low	0.57 (0.06, 5.34)	0.25 (-0.19, 0.68)	0.21 (-0.22, 0.65)	0.07 (-0.37, 0.50)	0.23 (-0.21, 0.68)
Paternal educational level					
High	Reference	Reference	Reference	Reference	Reference
Mid-high	0.54 (0.26, 1.15)	-0.08 (-0.22, 0.06)	-0.07 (-0.21, 0.07)	-0.03 (-0.17, 0.11)	-0.02 (-0.16, 0.12)
Mid-low	0.38 (0.15, 0.97)	-0.03 (-0.19, 0.13)	-0.01 (-0.17, 0.16)	-0.04 (-0.21, 0.12)	-0.06 (-0.23, 0.11)
Low	0.51 (0.14, 1.80)	-0.09 (-0.35, 0.18)	-0.10 (-0.37, 0.16)	0.01 (-0.26, 0.27)	-0.13 (-0.40, 0.15)
Net household income					
More than €3200/month	Reference	Reference	Reference	Reference	Reference
€2000-€3200/month	1.84 (0.83, 4.09)	0.06 (-0.10, 0.21)	0.02 (-0.13, 0.18)	0.07 (-0.08, 0.22)	0.05 (-0.11, 0.21)
Less than €2000/month	1.69 (0.37, 7.82)	-0.28 (-0.60, 0.05)	**-0.37 (-0.70, -0.05)**	0.15 (-0.18, 0.47)	0.07 (-0.26, 0.41)
Financial difficulties (Yes)	0.85 (0.34, 2.12)	-0.004 (-0.19, 0.18)	-0.04 (-0.22, 0.15)	0.05 (-0.13, 0.23)	-0.01 (-0.20, 0.18)
Paternal unemployment	0.62 (0.08, 5.02)	0.10 (-0.22, 0.43)	0.08 (-0.25, 0.41)	0.04 (-0.29, 0.36)	0.05 (-0.29, 0.39)
Maternal unemployment	1.29 (0.53, 3.13)	0.10 (-0.09, 0.30)	0.17 (-0.03, 0.37)	-0.12 (-0.31, 0.08)	-0.10 (-0.30, 0.11)

Table A4. Continued.

	OR (95% CI)	z Score change (95% CI)			
	Current asthma	FEV_1	FVC	FEV_1/FVC	FEF_{75}
	n=4,420	n=4,641	n=4,641	n=4,641	n=4,641
Ethnic background					
Dutch	Reference	Reference	Reference	Reference	Reference
Other western	0.90 (0.33, 2.43)	0.10 (-0.09, 0.29)	0.16 (-0.03, 0.35)	-0.08 (-0.28, 0.11)	0.01 (-0.18, 0.21)
Non-western	0.88 (0.36, 2.19)	-0.08 (-0.25, 0.09)	**-0.23 (-0.41, -0.06)**	**0.26 (0.09, 0.44)**	0.15 (-0.03, 0.33)

Bold print indicates statistical significance.
All sociodemographic factors were in the model.
* Models were adjusted for child's gender, exact age at measurement, birth weight, gestational age, ever eczema at age 9 years, respiratory tract infections, maternal age at enrollment, marital status, parity, maternal smoking during pregnancy, ever breastfeeding, pets exposure at home, daycare attendance and maternal BMI before pregnancy.

Table A5. Associations of sociodemographic factors with lung function in children without current asthma at 10 years of age (N=3,636).

	z Score change (95% CI)			
	FEV_1	FVC	FEV_1/FVC	FEF_{75}
Maternal educational level				
High	Reference	Reference	Reference	Reference
Mid-high	0.01 (-0.09, 0.11)	0.07 (-0.03, 0.17)	-0.09 (-0.19, 0.01)	-0.03 (-0.13, 0.07)
Mid-low	-0.03 (-0.15, 0.09)	0.05 (-0.07, 0.17)	-0.14 (-0.26, -0.01)	-0.03 (-0.15, 0.10)
Low	0.20 (-0.02, 0.42)	0.24 (0.02, 0.46)	-0.05 (-0.27, 0.17)	0.03 (-0.19, 0.25)
Paternal educational level				
High	Reference	Reference	Reference	Reference
Mid-high	-0.03 (-0.13, 0.08)	-0.05 (-0.16, 0.05)	0.04 (-0.07, 0.14)	0.04 (-0.07, 0.14)
Mid-low	-0.07 (-0.19, 0.05)	-0.08 (-0.20, 0.04)	-0.01 (-0.12, 0.11)	-0.01 (-0.13, 0.12)
Low	-0.03 (-0.20, 0.14)	-0.03 (-0.19, 0.15)	-0.001 (-0.17, 0.17)	-0.04 (-0.21, 0.13)
Net household income				
More than €3200/month	Reference	Reference	Reference	Reference
€2000-€3200/month	0.02 (-0.09, 0.13)	-0.01 (-0.12, 0.10)	0.05 (-0.06, 0.15)	0.02 (-0.09, 0.13)
Less than €2000/month	-0.13 (-0.32, 0.06)	**-0.21 (-0.40, -0.01)**	0.12 (-0.07, 0.31)	0.08 (-0.12, 0.27)
Financial difficulties				
No	Reference	Reference	Reference	Reference
Yes	0.14 (0.02, 0.26)	0.07 (-0.05, 0.19)	**0.13 (0.01, 0.24)**	0.10 (-0.02, 0.22)
Paternal unemployment				
Paid job	Reference	Reference	Reference	Reference
No paid job	-0.06 (-0.26, 0.15)	-0.004 (-0.21, 0.20)	-0.09 (-0.30, 0.12)	-0.11 (-0.32, 0.09)

Table A5. Continued.

	z Score change (95% CI)			
	FEV_1	FVC	FEV_1/FVC	FEF_{75}
Maternal unemployment				
Paid job	Reference	Reference	Reference	Reference
No paid job	0.03 (-0.08, 0.15)	0.10 (-0.02, 0.22)	**-0.12 (-0.23, -0.001)**	-0.08 (-0.20, 0.04)
Ethnic background				
Dutch	Reference	Reference	Reference	Reference
Other western	0.13 (-0.003, 0.27)	0.13 (-0.002, 0.27)	0.02 (-0.11, 0.16)	0.08 (-0.06, 0.22)
Non-western	-0.11 (-0.23, 0.004)	**-0.26 (-0.37, -0.15)**	**0.26 (0.15, 0.38)**	0.13 (0.01, 0.24)

Bold print indicates statistical significance.
All sociodemographic factors were in the model.
Models were adjusted for maternal age at enrollment, marital status and parity.

Table A6. Associations of sociodemographic factors with lung function in children with current asthma at 10 years of age (N=188).

	z Score change (95% CI)			
	FEV_1	FVC	FEV_1/FVC	FEF_{75}
Maternal educational level				
High	Reference	Reference	Reference	Reference
Mid-high	0.15 (-0.50, 0.81)	-0.09 (-0.81, 0.63)	0.40 (-0.37, 1.18)	0.19 (-0.40, 0.79)
Mid-low	-0.49 (-1.24, 0.26)	**-1.01 (-1.84, -0.18)**	0.83 (-0.06, 1.72)	0.38 (-0.30, 1.05)
Low	-0.89 (-2.16, 0.38)	-1.29 (-2.70, 0.11)	0.71 (-0.82, 2.24)	0.42 (-0.73, 1.58)
Paternal educational level				
High	Reference	Reference	Reference	Reference
Mid-high	0.03 (-0.61, 0.68)	0.10 (-0.61, 0.81)	-0.14 (-0.90, 0.63)	-0.07 (-0.65, 0.52)
Mid-low	0.14 (-0.57, 0.85)	0.01 (-0.78, 0.80)	0.21 (-0.64, 1.06)	0.08 (-0.57, 0.72)
Low	0.88 (-0.14, 1.89)	0.59 (-0.54, 1.71)	0.39 (-0.83, 1.62)	0.43 (-0.49, 1.35)
Net household income				
More than €3200/month	Reference	Reference	Reference	Reference
€2000-€3200/month	0.31 (-0.34, 0.97)	0.52 (-0.21, 1.25)	-0.22 (-1.00, 0.56)	-0.12 (-0.72, 0.47)
Less than €2000/month	0.24 (-0.96, 1.42)	0.48 (-0.83, 1.80)	-0.53 (-2.00, 0.95)	-0.27 (-1.35, 0.81)
Financial difficulties				
No	Reference	Reference	Reference	Reference
Yes	**-0.72 (-1.37, -0.07)**	**-0.72 (-1.44, -0.01)**	0.02 (-0.76, 0.80)	0.002 (-0.59, 0.59)
Paternal unemployment				
Paid job	Reference	Reference	Reference	Reference
No paid job	**-1.63 (-3.25, -0.01)**	-0.78 (-2.56, 1.01)	-1.31 (-3.26, 0.64)	-1.17 (-2.63, 0.30)

Table A6. Continued.

	z Score change (95% CI)			
	FEV_1	FVC	FEV_1/FVC	FEF_{75}
Maternal unemployment				
Paid job	Reference	Reference	Reference	Reference
No paid job	0.52 (-0.18, 1.22)	0.45 (-0.32, 1.22)	0.13 (-0.70, 0.95)	0.16 (-0.47, 0.79)
Ethnic background				
Dutch	Reference	Reference	Reference	Reference
Other western	0.10 (-0.87, 1.06)	-0.14 (-1.20, 0.93)	0.33 (-0.84, 1.49)	0.47 (-0.40, 1.35)
Non-western	-0.28 (-0.90, 0.34)	-0.41 (-1.09, 0.28)	0.15 (-0.58, 0.88)	-0.10 (-0.65, 0.46)

Bold print indicates statistical significance.
All sociodemographic factors were in the model.
Models were adjusted for maternal age at enrollment, marital status and parity.

3

Associations between the change in socioeconomic status over time and child health outcomes

CHAPTER 6

Family poverty dynamics and child health at age 6 years: the Generation R Study

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Submitted for publication

Abstract

Objectives

This study aims to assess the associations over time between poverty and child weight status, asthma, and health-related quality of life (HRQoL).

Methods

We analyzed data for 3,968 children from the Generation R Study, a population-based cohort study in the Netherlands. Net household income and the number of adults and children living from this income were measured at four time-points (during pregnancy, and at ages 2, 3 and 6). Poverty was defined based on the equivalised household income being less than 60% of the median national income. Child health outcomes were measured at age 6 years. The association was explored using logistic/linear regression models.

Results

In this cohort, 9.8% of children were born into poverty, and 6.0% had experienced 3–4 episodes of poverty. Independently of current poverty status, children born into poverty had an OR of 1.68 for being overweight/obese, and a lower physical HRQoL (OR= -1.32) than those not born into poverty. Children having experienced 3–4 episodes of poverty had an OR of 1.94 for having asthma, and a lower physical HRQoL (OR= -3.32) compared with children from never-poor families. Transition out of poverty before age 2 was associated with lower risk of asthma and a higher physical HRQoL compared with children remained in poor.

Conclusions

Being born into poverty or experiencing multiple episodes of poverty is associated with negative child health outcomes, such as being overweight, having asthma or a lower HRQOL. Support for children and families with a low household income is warranted.

Introduction

Poverty is an important risk factor for adverse child health outcomes [1]. Previous research suggests that poverty is associated with a higher chance of preterm birth for the child [2], lack of school readiness [3], and adverse long-term social and psychological outcomes [4]. Following a life-course approach [5], poverty may affect child health during sensitive periods. For instance, being born into poverty [6, 7] and/or the accumulation of poverty over time [8], result in more adverse health outcomes. Identifying how the timing and accumulation of poverty are associated with child health outcomes may offer insights into who could best be offered support, and at what point in time.

Evidence for the impact of poverty status on children's health outcomes is mainly related to cognitive development and school achievement [9]. The associations between poverty status and child physical health (e.g. weight status, chronic conditions) have not been studied sufficiently over time. A systematic review showed that 30 out of 34 studies included children's educational attainment, cognitive development, and social behavior as outcomes [9]. Only eight studies focused on the impact of income on children's physical health, and the results of these studies were mixed [9-11]. In addition, a subjective perception of children's physical, psychological, and social functioning, i.e. health-related quality of life (HRQoL), provides a broader view of the impact of poverty on child health. HRQoL studies with regard to the impact of poverty among children are scarce.

In the present study, we assessed child health outcomes at the level of symptoms, functioning, and overall quality of life [12]. We assessed weight status, asthma, and HRQoL in children aged 6 years, and related these to both poverty at birth and poverty over time. The aims of the present study were two-fold. First, we examined whether the timing, namely whether the child was born into poverty, and accumulation of poverty, the number of episodes of poverty from birth until child age 6 years, are associated with child weight status, asthma, and HRQoL at child age 6 years. Second, we evaluated whether the transition into or out of poverty before age 2 was associated with child health outcomes at age 6 years. We hypothesized that children who were born into poverty, and children living in families who experienced more episodes of poverty between birth and age 6 years, have a higher risk of overweight/obesity and asthma, and a lower HRQoL. We expected that transition out of poverty after age 2 would be associated with unfavorable child health outcomes at age 6 years [3].

Methods

Study design

The study was embedded in the Generation R Study, which is a prospective population-based cohort study performed in Rotterdam, the Netherlands. Details of the methodology of the study have been published previously [13]. The Study was approved by the Medical Ethics Committee of the Erasmus University Medical Centre (MEC 217.595/2002/202). All pregnant women whom had a delivery date between 1 April 2002 and 31 January 2006, living in the study area, were invited to participate in the study. A total of 8,305 children participated in the study at age 6 years. Children with net household income measurements at least three time points (during pregnancy, and at ages 2, 3, and 6) were included in the study (N=4,495). In total, 154 children did not have any data available regarding the health outcome measurements (weight status, asthma, and HRQoL) and were therefore excluded. To avoid clustering of data, second (n=368) and third children (n=5) of the same mother were excluded, leaving a study population of 3,968 participants. Written informed consent was obtained from all participants.

Poverty status

Parents were asked to indicate the net household income category in a multiple-choice question (e.g. 3200–4000 euros per month) at 4 time points (during pregnancy, and at child ages 2, 3, and 6 years). This amount included monthly income from work, benefits, and/or income from assets, that they received in-hand after tax and contributions had been deducted. Parents were also asked about the number of adults and children in the household (i.e. the number of "units") living from this income. We assigned a mean income (e.g. 3600 euros for "3200–4000 euros per month") to each category. Equivalised total household income (income/unit) was calculated during pregnancy, and at child ages 2, 3, and 6 years [14]. Poverty at birth, and at ages 2, 3, and 6 years (yes/no) was defined based on the equivalised total household income of less than 60% of the median national income per unit according to the Organization for Economic Co-operation and Development (OECD) household equivalence scale [15, 16]. A missing measurement of poverty was considered as 'not poor'.

Poverty status was defined in two ways: poverty at birth, and cumulative poverty. Poverty at birth (yes/no) was defined using the measure during pregnancy [6]. Cumulative poverty was defined by the number of episodes of poverty in between pregnancy and child age 6 years: never poor (i.e. no episodes of poverty), intermittently poor (i.e. 1–2 episodes of poverty), or chronically poor (i.e. 3–4 episodes of poverty) [8].

With regard to the second study question, the timing of poverty change was classified as occurring before or after age 2 [3]. Two separate sub-cohorts were created. One cohort consisted of children who were born into poverty (n=328). The timing of poverty change was defined as: no change, transition out of poverty before age 2, or transition out of poverty after age 2. The other cohort consisted of children who were born outside of poverty (n=3,640). The timing of poverty change was defined as: no change, transition into poverty before age 2, or transition into poverty after age 2.

Health outcomes

Three health outcomes were used as indicators of child health status at age 6 years: weight status (overweight/obese vs normal weight), asthma (yes/no), and HRQoL. Height and weight (in lightweight clothes and without shoes) were measured at the Generation R research center in the Erasmus Medical Center, Sophia's Children's Hospital. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Children were categorized as overweight (including obesity) or normal weight, according to international age- and sex-specific BMI cut-off points [17]. Information on whether the child had ever received a physician diagnosis of asthma was obtained using a questionnaire with adapted items from the International Study of Asthma and Allergies in Childhood core questionnaires [18]. HRQoL was measured using the CHQ-PF28. There are 28 items with four-, five-, or six-response options across 13 scales in the CHQ-PF28. The items from each of the scales were summed and transformed into 0 (lowest) to 100 (highest level of health) [19]. Ten scales were utilized in scoring a two-dimensional summary: physical summary component scale (PhS), and the psychosocial summary component scale (PsS) [20]. Both summary scales were considered to be the main outcomes of the CHQ-PF28.

Potential confounders

Several maternal and child characteristics were included: maternal age, maternal educational level, child's sex, age, and ethnic background. Maternal age (years) and educational level were obtained using a questionnaire at enrollment. Maternal educational level was categorized into three levels: low (no education, primary school, pre-vocational education, intermediate general education, or 4 years of general secondary education), middle (5 years or more general secondary education or intermediate vocational education), and high (higher vocational education, university, or higher academic education). Child ethnic background (western, non-western) was based on the parents' country of birth, which was assessed using questionnaires when the child was 6 years old. If one of the parents was born outside the Netherlands, this country of birth determined the ethnic background of the child. If both parents were born outside the Netherlands, the country of birth of the mother determined the ethnic background [21].

Statistical Analyses

Descriptive statistics were used to describe poverty and child health outcomes in the sample. Logistic regression models were used to study the associations between poverty status and categorical outcomes (weight status and asthma). Linear regression models were used to study the associations between poverty status and HRQoL. Adjusted logistic/linear regression models were used to correct for potentially confounding variables; both maternal (maternal age, maternal educational level) and child (sex, age, and ethnic background) variables were included. Models of associations between poverty at birth and child health outcomes were additionally adjusted for poverty at child age 6 years to study the associations independently of the current poverty situation.

Interactions were tested between ethnic background and poverty status to verify whether the associations between poverty status and child health outcomes differed by child ethnic background. Apart from an interaction between ethnic background and being born into poverty regarding psychosocial HRQoL, no statistically significant interactions were found.

Five imputed datasets were generated using a fully conditional specified model, based on the relationships between the variables included in this study. Pooled effect estimates (ORs and beta coefficients) and the 95% confidence intervals (CIs) from these five imputed datasets were reported. Associations were evaluated at the $P<0.05$ level. Statistical analyses were performed using IBM SPSS Statistics for Windows, version 24.0. Armonk, NY: IBM Corp.

Results

Poverty status from pregnancy until age 6 years

Of the 3,968 children in the cohort, 328 (9.8%) were born into poverty. Up to child age 6 years, 411 (10.4%) of their families had experienced 1 or 2 episodes of poverty since pregnancy and 238 (6.0%) had experienced 3 or 4 episodes of poverty. Thus 649 (16.4%) of the children had spent at least one year into poverty before the age of 6 years (Table 1).

Children born into poverty had higher rates of overweight/obesity (27.7%) and asthma (11.5%) at age 6 years than those not born poor (both $P<0.001$) (Table 2). Physical HRQoL score was lower in 6-year-old children born into poverty (mean: 55.56; SD: 8.13) than those not born poor (mean: 57.58; SD: 5.95) ($P<0.001$). Children who lived in chronically poor families had the highest rates of overweight/obesity (23.4%), and asthma (13.2%), and the lowest physical HRQOL score (mean: 54.17; SD: 9.01) (Table 2).

Associations between poverty status and health outcomes

In Table 3, we summarize the odds and beta coefficients of each child's health outcomes according to the family poverty status. After adjustment for confounders and current poverty status, children who were born into poverty had an OR of 1.68 (95% CI: 1.21, 2.32) for being overweight/obese at age 6 years, and they were at higher risk of having a lower score for physical HRQoL (-1.32; 95% CI: -2.25, -0.39) than those not born into poverty. Children from chronically poor families had an OR of 1.94 (95% CI: 1.10, 3.41) for having asthma compared with children from never-poor families, and they were at higher risk of having a lower score on physical HRQoL (-3.32; 95% CI: -4.42, -2.22). Children from families experiencing intermittent poverty had an OR of 1.36 (95% CI: 1.01, 1.84) for being overweight/obese, but the association was not significant among children who lived in chronically poor families (OR: 1.15; 95% CI: 0.78, 1.69).

Table 1. Characteristics of children and their families (N=3,968)

Characteristic		Finding N (%)	Missing N (%)
Family characteristics			
Maternal educational level	High	2,280 (59.4)	128 (3.2)
	Middle	1,056 (27.5)	
	Low	504 (13.1)	
Poverty during pregnancy (yes)		328 (9.8)	614 (15.5)
Poverty at child age 2 years (yes)		343 (9.2)	238 (6.0)
Poverty at child age 3 years (yes)		350 (9.7)	347 (8.7)
Poverty at child age 6 years (yes)		336 (9.0)	228 (5.7)
Cumulative poverty	0 episode	3,319 (83.6)	0
	1–2 episodes	411 (10.4)	
	3–4 episodes	238 (6.0)	
Children's characteristics			
Sex	Boy	1,985 (50.0)	0
	Girl	1,983 (50.0)	
Age	Months (SD)	5.9	0.3
Ethnic background	Western	3,074 (77.5)	4 (0.1)
	Non-western	890 (22.5)	
Weight status	Normal	3,163 (86.6)	317 (8.0)
	Overweight/obese	488 (13.4)	
Asthma diagnosis (yes)		201 (6.0)	636 (16.0)
CHQ-PF28 Physical summary score, mean (SD)		57.44 (6.15)	576 (14.5)
CHQ-PF28 Psychosocial summary score, mean (SD)		53.01 (6.73)	576 (14.5)

The table is based on a non-imputed dataset.

Table 2. Distribution of health outcomes in 6-year-old child according to poverty status (N=3,968)

Poverty status	Overweight/ obese	Asthma	Quality of life	
	(N=488)	(N=201)	PhS scale	PsS scale
Born into poverty	**P<0.001**	**P<0.001**	**P<0.001**	P=0.73
No	401 (12.0)	173 (5.6)	57.58 (5.95)	53.03 (6.68)
Yes	87 (27.7)	28 (11.5)	55.56 (8.13)	52.87 (7.36)
Cumulative poverty	**P<0.001**	**P<0.001**	**P<0.001**	**P=0.03**
Never poor	345 (11.4)	158 (5.5)	57.66 (5.92)	53.07 (6.56)
Intermittently poor	89 (22.6)	20 (6.8)	57.09 (5.90)	52.13 (7.95)
Chronically poor	54 (23.4)	23 (13.2)	54.17 (9.01)	53.66 (7.11)

The table is based on a non-imputed dataset. Chi-square tests were used for categorical variables and ANOVA were used for continuous variables.
Bold print indicates statistical significance.
PhS scale: physical summary component scale; PsS scale: psychosocial summary component scale.

Table 3. Associations between poverty status and child health outcomes (N=3,968)

Poverty status	Overweight/ obese	Asthma	Quality of life	
			PhS	PsS
	OR (95% CI)	OR (95% CI)	B (95% CI)	B (95% CI)
Born into poverty*				
Not poor	Ref	Ref	Ref	Ref
poor	**1.68 (1.21, 2.32)**	1.62 (0.97, 2.72)	**-1.32 (-2.25, -0.39)**	0.30 (-0.73, 1.33)
Cumulative poverty				
Never poor	Ref	Ref	Ref	Ref
Intermittently poor	**1.36 (1.01, 1.84)**	1.04 (0.62, 1.75)	-0.63 (-1.41, 0.16)	-0.63 (-1.50, 0.24)
Chronically poor	1.15 (0.78, 1.69)	**1.94 (1.10, 3.41)**	**-3.32 (-4.42, -2.22)**	0.80 (-0.42, 2.02)

The table is based on an imputed dataset.
Models adjusted for maternal age, maternal educational level, child's sex, age, and ethnic background. Bold print indicates statistical significance.
* Models additionally adjusted for poverty at child age 6 years.

Timing of poverty change

Children born into poverty, whose family became non-poor before they turned 2 years of age, had an OR of 0.29 (95% CI: 0.11, 0.81) for having asthma, and a higher score for physical HRQoL (4.57; 95% CI: 1.73, 7.41) compared with children who remained in a poor family (Table 4). Children born outside of poverty, whose family became poor before they turned 2 years of age, had a lower score for physical HRQoL (-1.97; 95% CI: -3.13, -0.82). Changes after age 2 were not associated with either health outcome.

Discussion

This study aimed to examine the associations of family poverty status from pregnancy onwards up to child age 6 years, with child health outcomes for weight status, asthma, and HRQoL at 6 years. The results showed that around ten percent (9.8%) of children were born into poverty. More than fifteen percent (16.4%) of the families experienced at least 1 episode of poverty between the time the child was born and age 6 years.

Consistent with our hypotheses, we observed associations between family poverty status and child health outcomes. Poverty in early childhood was associated with an increased risk of overweight/obesity. Accumulation of poverty between pregnancy and age 6 years was associated with a higher risk for asthma. Both poverty at birth and cumulative poverty were associated with lower physical HRQoL. Transition out of poverty before age 2 was associated with lower risk of asthma and a higher physical HRQoL compared with children remained in poor.

To guide the interpretation of the associations, two available models can help explain the different associations we observed between the measures of poverty status and child health outcomes [22, 23]. First, in accordance with accumulation models, the duration of poverty plays an important role because the impact of poverty accumulates over time [24]. In our study, chronic poverty was associated with higher odds of asthma, which is in line with several previous studies [8, 10]. One study reported that poverty in the first and fourth years of a child's life is associated with a higher risk of asthma attacks at age 4 years [10]. Another study found that among children aged three-and-a-half years, children from chronically poor families had a greater probability of experiencing asthma attacks than children from never-poor families [8]. Family stress has been reported to be more prevalent in families with cumulative poverty [25]. There is a considerable amount of literature indicating an association between child exposure to stress and the development of asthma [26-28]. These studies suggest that family stress may play a role in the pathway between cumulative poverty and childhood asthma.

Table 4. Associations between timing of poverty change and child health outcomes

	Overweight/obesity	Asthma	Quality of life	
			PhS	PsS
	OR (95% CI)	OR (95% CI)	B (95% CI)	B (95% CI)
Born into poverty (n=328)				
No change	Ref	Ref	Ref	Ref
Transition out of poverty before age 2	2.06 (0.97, 4.36)	**0.29 (0.11, 0.81)**	**4.57 (1.73, 7.41)**	-0.18 (-2.79, 2.44)
Transition out of poverty after age 2	1.77 (0.81, 3.87)	0.38 (0.13, 1.10)	**3.69 (0.69, 6.69)**	-0.94 (-3.70, 1.83)
Not born into poverty (n=3640)				
No change	Ref	Ref	Ref	Ref
Transition into poverty before age 2	1.00 (0.62, 1.60)	0.84 (0.33, 2.13)	**-1.97 (-3.13, -0.82)**	0.02 (-1.29, 1.33)
Transition into poverty after age 2	1.03 (0.63, 1.69)	1.36 (0.92, 2.00)	0.27 (-0.93, 1.47)	-0.89 (-2.25, 0.47)

The table is based on an imputed dataset.
Models adjusted for maternal age, maternal educational level, child's sex, age and ethnic background. Bold print indicates statistical significance.

Second, period models suggest that family income at a certain time point is more critical to health [29]. Previous studies have shown that poverty in early life is a sensitive period for poorer academic achievement [30], adolescent smoking [6], and adolescent overall health status [31]. Our results add to the evidence that poverty at birth is associated with a higher risk of overweight/obesity, and a lower physical HRQoL at 6 years of age. These associations were independent of the current family poverty status. In conclusion, support for children whose families experience poverty early in life may have an important impact on health later in childhood and in adulthood.

The associations between poverty status and health may vary according to different health outcomes, and also with the child's age [8]. Chen et al. (2007) found no association between lower cumulative family income and asthma in either 10–11-year-olds or 14 –15-year-olds [22]. Kakinami et al. (2014) found that children from stable poor households were at higher risk of being overweight or obese at age 8 years, 10 years, and 12 years, but not at age 6 years [23]. Understanding the history of family income from birth onwards may provide more information on the value of assessing various child health outcomes at different ages.

Our study adds to the evidence on the association between poverty status and HRQoL by showing that children who were born into poverty, or experienced chronic poverty, had lower physical HRQoL. Any exposure to poverty was associated with lower physical HRQoL. That poverty status was not associated with psychosocial HRQoL might result from the young age of this population. Future studies observing children from a younger age until adolescence are warranted to provide greater insights into the associations between poverty status and child HRQoL.

A study in Canada showed that children whose family left or transitioned into poor neighborhoods before the child was aged 2 showed significant differences in school readiness compared with children whose family left or transitioned into poor neighborhoods after age 2 [3]. Our results demonstrated that transition out of poverty before age 2 was associated with a higher physical HRQoL and lower risk of asthma compared with children whose family remained in poor. Transitions into or out of poverty after age 2 were not associated with either health outcome. Further studies are needed to examine the impact of the timing of poverty change.

A strength of this study is the longitudinal design; net household income was measured at four different time points, from prenatal to child age 6. We were, therefore, able to identify the associations between the dynamics of poverty and various health outcomes. This study also benefitted from a large sample size. Nevertheless, some limitations should be considered. First, poverty was measured by self-reported household income rather than from official records. Additionally, children with missing data on net household income at more than one time-point were excluded from the analyses. This could have led to a selection bias in the case where parents with the highest or lowest income tend to not report their family situation. However, our results showed that the level of poverty in this study is comparable to that observed in the whole of the Netherlands [32, 33]. Second, information on whether the child received a physician diagnosis of asthma was obtained using a questionnaire, which was adapted from the ISAAC Core Questionnaire. This questionnaire is considered to be a reliable instrument, and sufficient for epidemiologic studies [34]. However, misclassification due to self-reporting may be present.

Conclusion

Children born into poverty were found to have higher risk of overweight/obesity. Children growing up in chronically poor families are more at risk of asthma and a lower physical quality of life than children never experiencing poverty. Transition out of poverty in early age was associated with lower risk of asthma and a higher physical quality of life. Support for children whose families have a low household income is warranted.

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CHAPTER 7

Social mobility by parent education and childhood overweight and obesity: The Generation R Study

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Abstract

Background
The association of social mobility, measured by parent education, and childhood overweight and obesity (OWOB) has been scarcely reported on. This study evaluated the associations between social mobility measured by parent education and childhood OWOB at child age six and ten years.

Methods
We analyzed data of 4,030 children and parents participating in the Generation R study. We used generalized linear models controlling for potential confounders to determine if social mobility (upward mobility, static-low and static-high based on the change of parent education) was associated with age- and sex-specific standard-deviation scores of body mass index (BMI-SDS) or OWOB (the cut-offs of International Obesity Task Force).

Results
Mean BMI-SDS of the children was 0.23±0.89 and 0.25±1.03 at child age six and ten years respectively; the prevalence of OWOB increased from 15.3% to 17.3%. Compared with children from mothers in the upward mobility group, children from mothers in the static-high group had lower BMI-SDS and lower risk of OWOB at both ages (All $P<0.001$). Compared with children from fathers in the upward mobility group, children from fathers in static-low group had higher BMI-SDS and higher risk of OWOB at both ages (All $P<0.05$).

Conclusions
Our study contributes to the literature by showing that attaining a high education level after birth for both mothers and fathers can be beneficial to attenuate the risk of the child having overweight or obesity at child age six and ten years.

Introduction

The rising pandemic and the increasing burden of obesity especially in children has received major attention worldwide [1]. Even though a flattened trend of body mass index (BMI) in children (5-19 years) was observed in Northwestern Europe in recent years [2], the prevalence of obesity is still higher in the children from lower educated families [3]. Therefore, the socioeconomic inequalities in childhood overweight and obesity (OWOB) remain in Europe [4].

Among different markers of socio-economic position (SEP), maternal education level is a strong predictor of the development of childhood OWOB [3, 5-10]. Parents especially mothers with high education may take greater advantage of positive parenting practices on children's obesity-related lifestyles and enhanced acquisition of the familial and residential environment [11-13]. Although more women attain a higher education level after having children nowadays [14], studies seldom took into account the change of maternal education level when studying child health outcomes. In addition, paternal education level alone is even less investigated [3, 5-10]. Therefore, it's of importance to understand both the role of maternal and paternal education and its association with childhood OWOB.

Social mobility can be defined as downward or upward change in SEP [15], and occur within (intra-generational) or between (intergenerational) generations [15]. Social mobility has been well studied with regard to adult obesity, with a focus on the intra-generational social mobility across the life course. Several studies showed that adults with a static-low SEP across the life course also have a higher risk of ever having OWOB [16-18]. As for intergenerational social mobility, a cross-sectional study in Germany suggested that if children of low educated families attained a high education level they had lower risk of being overweight/obese in adolescence (12-17 years) [19]. To our knowledge, only one study conducted in Brazil has examined associations between social mobility and childhood OWOB taking the change of parent education as starting point, and they didn't observe a significant impact of social mobility on childhood OWOB [20]. Since this study was conducted in a developing country, thus far it is uncertain what the associations are in developed countries.

Research has demonstrated that parent education either in prenatal period or early childhood is crucial to the development of childhood OWOB [3, 6, 7], but, to our knowledge, no study has yet explored the relationship between the increase of parent education during childhood and the occurrence of childhood OWOB. Hence, the current study used measures of parent education both in pregnancy (i.e. the prenatal period) and early childhood (i.e. child age six years). We aimed to investigate the association of (1) parent education in pregnancy; (2) parent education in early childhood and (3) the change of parent education between these time points, with child BMI-standard deviation score (BMI-SDS) and OWOB measured at child age six and ten years.

Methods

Study design and population

This study was embedded in the Generation R Study, an ongoing population-based cohort from fetal life onwards in the Netherlands [21]. The study was conducted in accordance with the guidelines proposed in the World Medical Association's Declaration of Helsinki and was approved by the Medical Ethical Committee of the Erasmus MC, University Medical Center Rotterdam (MEC-2012-165). Pregnant women were invited to participate with an expected delivery date between April 2002 and January 2006. Consent for postnatal follow-up was available for 7,121 children who visited the research center for measures at child age six and ten years. Children were excluded if: (1) the information on maternal education level (both in pregnancy and early childhood) was missing (N=1,680); (2) the data on weight and height at age six and ten years was missing (N=935) and (3) twin pregnancies (N=112) and the second or third child of the same mother (N=264), yielding a final sample size of 4,030 participants for the analyses. The relationship between paternal education level and OWOB builds on a simplified cohort. This cohort further excluded children whose information on paternal education level (both in pregnancy and early childhood) was missing (N=1,364), yielding a sample size of 2,666 participants for the analyses. The flowchart is shown in **Supplemental Figure 1**.

Assessment and coding of parent education

We obtained information of parent education by using parent self-report questionnaires in pregnancy and early childhood. The highest completed education level was classified into two categories: (1) low (no education, primary school, lower vocational training, intermediate general school, or 3 years or less general secondary school); (2) high (>3 years general secondary school, intermediate vocational training, university or PhD degree, and higher vocational training). Social mobility was classified into three categories based on whether the highest completed education level of the parents changed upward, or stayed static from pregnancy to early childhood [22]. The following categories of social mobility were defined: (1) static-high group (high to high); (2) static-low group (low to low) and (3) upward mobility group (low to high).

Assessment of childhood OWOB

Trained staff of the Erasmus University Medical Center measured children's height and weight using standard procedures at child age six and ten years [21]. Height was measured in standing position using a Harpenden stadiometer, while weight was measured with light clothing using a mechanical personal scale. We calculate the body mass index [BMI, weight (kg)/height (m)^2] and expressed as age- and sex-specific BMI-SDS based on the Dutch 1997 growth reference [23]. Children were categorized as being overweight or obese (yes/no) using the gender-specific cut-off values from Cole et al [24].

Potential confounders

Maternal age was obtained at enrollment by parent-report questionnaires. Information on birth weight was obtained from medical records. Child ethnic background (Dutch, other Western, non-Western) was based on the country of birth of the parents, which was assessed by questionnaires when the child was six years old. If one of the parents was born outside the Netherlands, this country of birth determined the ethnic background of the child. If both parents were born outside the Netherlands, the country of birth of the mother determined the ethnic background [25].

Statistical analyses

Multivariate linear and logistic regression models were used to analyze the associations of parent education with childhood weight status at two time points separately, and the social mobility using parent education with the BMI-SDS and the odds of OWOB, respectively. We created two sets of models. Model 1 was a crude model without adjusting for any potential confounders. Model 2 was adjusted for potential confounders including maternal age, child ethnic background and child birth weight.

We report the Beta (β) estimates of the linear models, and odd ratios (OR) of the logistic models using the upward mobility group as reference. We performed Wald test for the interaction term between education level and child sex or ethnic background since the association between SEP and overweight may differ by sex [3] or for children from different ethnic backgrounds [7]. Interaction between education level and child's sex were not significant; therefore analyses were not stratified for sex.

All statistical analyses were performed in the statistical software R 3.5.3 for Windows (R Core Team 2018). A *P* value of <0.05 for two-sided test was considered as statistically significant.

Results

Table 1 shows the characteristics of our study population. Mothers were enrolled at the mean age of 31.24±4.69 years. In total, 6.7% of the mothers and 8.8% of the fathers were in the upward mobility group: attaining a high education level between pregnancy and early childhood. Mothers and fathers in the static-low group (6.7% and 8.8%) and static-high group (82.9% and 82.2%) attained either low or high education level in pregnancy, and remained at this education until the measure in early childhood. Half of the children were boys (49.7%) and 64.0% of the children had a Dutch ethnic background. The children had a mean BMI-SDS of 0.23±0.89 and 0.25±1.03 measured at the mean age of 6.10±0.43 and 9.76±0.30 years, and the prevalence of OWOB increased from 15.3% to 17.3%. There were some small differences between the excluded and included participants in maternal age, parent education, birth weight and child ethnic background (Shown in **Supplemental Table 1**).

Table 1. The basic information of included children in the cohort (N=4,030)

	Mean (SD) or N (%)
Parental Characteristics	
Maternal age at enrollment (years)	31.24 (4.69)
Social mobility regarding maternal education level [α]	
Upward mobility group	272 (6.7%)
Static-high group	3,342 (82.9%)
Static-low group	416 (10.3%)
Social mobility regarding paternal education level [α] (missing=1,364)	
Upward mobility group	235 (8.8%)
Static-high group	2,191 (82.2%)
Static-low group	240 (9.0%)
Children's Characteristics	
Birth weight (grams, missing=5)	3437.86 (551.90)
Children's age measured at ten years	9.76 (0.30)
Sex	
boys	2002 (49.7%)
girls	2028 (50.3%)
Ethnic background	
Dutch	2580 (64.0%)
Other Western	354 (8.8%)
Non-Western	1096 (27.2%)
Children's Outcomes	
BMI-SDS at six years	0.23 (0.89)
Prevalence of OWOB at six years	616 (15.3%)
BMI-SDS at ten years	0.26 (1.03)
Prevalence of OWOB at ten years	697 (17.3%)

Abbreviation: BMI-SDS= body mass index-standard deviation scores; OWOB=overweight/obesity.
[α]: The highest completed education level was classified into two categories: (1) low (no education, primary school, lower vocational training, intermediate general school, or 3 years or less general secondary school); (2) high (>3 years general secondary school, intermediate vocational training, university or PhD degree, and higher vocational training). Social mobility was classified in three categories based on whether the highest completed education level of either the mother or the father changed upward, or stayed static from pregnancy to early childhood. The following categories of social mobility were defined: (1) static-high group (high to high); (2) static-low group (low to low) and (3) upward mobility group (low to high).

As shown in **Table 2,** we used parent education in pregnancy or early childhood as SEP indicators, and the results showed that children from parents with a low education level had a higher BMI-SDS (β ranged from 0.11 to 0.53) and a higher risk of OWOB (OR ranged from 1.67 to 2.86) at child age six and ten years compared to children from parents with a high education level (All $P<0.05$).

Table 3 shows the associations of social mobility with BMI-SDS and OWOB measured at child age six years. Compared with children from mothers in the upward mobility group, children from mothers in the static-high group had a lower BMI-SDS [β=-0.32, 95% confident interval (CI): -0.45, -0.20] and a lower risk of OWOB (OR=0.58, 95%CI: 0.42, 0.79) after adjustment for potential confounders. Compared with children from parents in the upward mobility group, children from parents in the static-low group had a higher BMI-SDS (β=0.16, 95%CI: 0.02, 0.31) and a higher risk of OWOB (OR=2.11, 95%CI: 1.30, 3.42).

Table 4 shows the associations of social mobility with BMI-SDS and OWOB at child age ten years. Compared with children from mothers in the upward mobility group, children from mothers in the static-high group had a lower BMI-SDS (β=-0.41, 95%CI: -0.53, -0.28) and a lower risk of OWOB (OR=0.52, 95%CI: 0.39, 0.71). Compared with children of fathers in the upward mobility group , children from fathers in the static-low group had a higher BMI-SDS (β=0.20, 95%CI: 0.03, 0.37), while children from fathers in the static-high group had a lower BMI-SDS (β=-0.18, 95%CI: -0.31, -0.05). Moreover, children from fathers in the static-low group also had a higher risk of OWOB (OR=1.88, 95%CI: 1.19, 2.97).

Interaction analyses

We found several significant interaction terms regarding maternal education level and child ethnic background; therefore analyses were stratified for child ethnic background (Shown in **Supplemental Table 2**). In Dutch population, a low education level measured in pregnancy was associated with a higher BMI-SDS (β=0.52, 95%CI: 0.41, 0.63) and a higher OR of being OWOB (3.26, 95%CI: 2.41, 4.43) at child age ten years. A low education level measured in early childhood was also associated with a higher BMI-SDS (β=0.59, 95%CI: 0.43, 0.74) and a higher OR of being OWOB (OR=3.59, 95%CI: 2.45, 5.25) at child age ten years. In the Dutch population, children from mothers in the static-high group had a lower risk of OWOB (OR=0.38, 95%CI: 0.25, 0.59) compared with children from mothers in the upward mobility group. For children from other Western and non-Western ethnic background the associations were less apparent.

Table 2. The association of parent education with BMI-SDS and OWOB at child age six and ten years [α].

Subgroup of parent education[β]	BMI-SDS [β (95%CI)]				OWOB [OR (95%CI)]			
	At 6y		At 10y		At 6y		At 10y	
	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted
Measured in pregnancy								
Maternal education level								
High (n=3,342)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Low (n=688)	**0.31**	**0.24**	**0.50**	**0.39**	**2.36**	**1.85**	**2.77**	**2.12**
	(0.24 – 0.38)	**(0.16 – 0.31)**	**(0.42 – 0.58)**	**(0.30 – 0.47)**	**(1.93 – 2.87)**	**(1.49 – 2.28)**	**(2.30 – 3.34)**	**(1.74 – 2.59)**
Paternal education level								
High (n=2,191)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Low (n=475)	**0.11**	**0.09**	**0.32**	**0.27**	**1.89**	**1.67**	**2.00**	**1.70**
	(0.03 – 0.19)	**(0.01 – 0.17)**	**(0.23 – 0.41)**	**(0.18 – 0.37)**	**(1.47 – 2.43)**	**(1.28 – 2.18)**	**(1.58 – 2.54)**	**(1.32 – 2.19)**
Measured in early childhood								
Maternal education level								
High (n=3,614)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Low (n=416)	**0.31**	**0.22**	**0.53**	**0.39**	**2.37**	**1.79**	**2.86**	**2.08**
	(0.22 – 0.40)	**(0.13 – 0.31)**	**(0.43 – 0.63)**	**(0.29 – 0.50)**	**(1.87 – 3.00)**	**(1.39 – 2.29)**	**(2.29 – 3.57)**	**(1.65 – 2.63)**
Paternal education level								
High (n=2,426)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Low (n=240)	**0.25**	**0.18**	**0.44**	**0.33**	**2.13**	**1.67**	**2.67**	**2.05**
	(0.17 – 0.33)	**(0.10 – 0.26)**	**(0.34 – 0.53)**	**(0.23 – 0.42)**	**(1.69 – 2.68)**	**(1.31 – 2.14)**	**(2.15 – 3.30)**	**(1.63 – 2.57)**

Abbreviation: BMI-SDS= body mass index-standard deviation scores; 95%CI=95% confidence interval; OWOB=overweight/obesity; β=estimates; OR=odd ratios.

[α]: The adjusted models were adjusted for child ethnic background, maternal age and birth weight.

[β]: The highest completed education level was classified into two categories: (1) low (no education, primary school, lower vocational training, intermediate general school, or 3 years or less general secondary school); (2) high (>3 years general secondary school, intermediate vocational training, university or PhD degree, and higher vocational training). Social mobility was classified in three categories based on whether the highest completed education level of either the mother or the father changed upward, or stayed static from pregnancy to early childhood. The following categories of social mobility were defined: (1) static-high group (high to high); (2) static-low group (low to low) and (3) upward mobility group (low to high).

Bold indicated all *P* value<0.05.

Table 3. The association of social mobility measured by parent education with BMI-SDS and OWOB at child age six years[α].

Subgroup of social mobility[β]	N	mean (SD)	β /OR (95%CI)			
			Crude	*P* value	Adjusted	*P* value
BMI-SDS measured at 6 y						
Maternal education level	4,030	0.23 (0.89)				
Upward mobility group	272	0.46 (1.03)	Ref		Ref	
Static-high group	3,342	0.17 (0.85)	**-0.28 (-0.39, -0.17)**	**<0.01**	**-0.22 (-0.33, -0.12)**	**<0.01**
Static-low group	416	0.50 (1.04)	0.05 (-0.09, 0.18)	0.51	0.02 (-0.12, 0.15)	0.79
Paternal education level	2,666	0.17 (0.84)				
Upward mobility group	235	0.18 (0.89)	Ref		Ref	
Static-high group	2,191	0.15 (0.82)	-0.02 (-0.13, 0.09)	0.72	-0.02 (-0.13, 0.10)	0.79
Static-low group	240	0.36 (1.02)	**0.18 (0.03, 0.33)**	**0.02**	**0.16 (0.02, 0.31)**	**0.03**
OWOB measured at 6 y						
Maternal education level	4,030	616 (15.3%)				
Upward mobility group	272	65 (23.9%)	Ref		Ref	
Static-high group	3,342	436 (13.1%)	**0.48 (0.36, 0.64)**	**<0.01**	**0.58 (0.42, 0.79)**	**<0.01**
Static-low group	416	115 (27.6%)	1.22 (0.86, 1.73)	**0.28**	1.11 (0.77, 1.60)	0.57
Paternal education level	2,666	344 (12.9%)				
Upward mobility group	235	31 (13.2%)	Ref		Ref	
Static-high group	2,191	252 (11.5%)	1.11 (0.77, 1.60)	0.57	0.92 (0.61, 1.39)	0.69
Static-low group	240	61 (25.4%)	**2.23 (1.39, 3.59)**	**<0.01**	**2.11 (1.30, 3.42)**	**<0.01**

Abbreviation: BMI-SDS= body mass index-standard deviation scores; 95%CI=95% confidence interval; OWOB=overweight/obesity; β=estimates; OR=odd ratios.
[α]: The adjusted models were adjusted for child ethnic background, maternal age and birth weight.
[β]: The highest completed education level was classified into two categories: (1) low (no education, primary school, lower vocational training, intermediate general school, or 3 years or less general secondary school); (2) high (>3 years general secondary school, intermediate vocational training, university or PhD degree, and higher vocational training). Social mobility was classified in three categories based on whether the highest completed education level of either the mother or the father changed upward, or stayed static from pregnancy to early childhood. The following categories of social mobility were defined: (1) static-high group (high to high); (2) static-low group (low to low) and (3) upward mobility group (low to high).

Table 4. The association of social mobility measured by parent education with BMI-SDS and OWOB at child age ten years [α].

Subgroup of social mobility [β]	N	No. (%)	β /OR (95%CI)			
			Crude	*P* value	Adjusted [β]	*P* value
BMI-SDS measured at 10 y						
Maternal education level	4,030	0.26 (1.03)				
Upward mobility group	272	0.58 (1.16)	Ref		Ref	
Static-high group	3,342	0.17 (0.98)	**-0.41 (-0.53, -0.28)**	**<0.01**	**-0.32 (-0.45, -0.20)**	**<0.01**
Static-low group	416	0.73 (1.15)	0.15 (-0.00, 0.31)	0.05	0.11 (-0.05, 0.26)	0.17
Paternal education level	2,666	0.19 (0.98)				
Upward mobility group	235	0.34 (0.99)	Ref		Ref	
Static-high group	2,191	0.14 (0.96)	**-0.20 (-0.33, -0.07)**	**<0.01**	**-0.18 (-0.31, -0.05)**	**<0.01**
Static-low group	240	0.57 (1.11)	**0.23 (0.05, 0.40)**	**0.01**	**0.20 (0.03, 0.37)**	**0.02**
OWOB measured at 10 y						
Maternal education level	4,030	697 (17.3%)				
Upward mobility group	272	76 (27.9%)	Ref		Ref	
Static-high group	3,342	479 (14.3%)	**0.20 (0.03, 0.37)**	**0.02**	**0.52 (0.39, 0.71)**	**<0.01**
Static-low group	416	142 (34.1%)	1.34 (0.96, 1.87)	0.09	1.19 (0.84, 1.68)	0.33
Paternal education level	2,666	382 (14.3%)				
Upward mobility group	235	38 (16.2%)	Ref		Ref	
Static-high group	2,191	277 (12.6%)	0.75 (0.52, 1.09)	0.13	0.83 (0.57, 1.22)	0.34
Static-low group	240	67 (27.9%)	**2.01 (1.28, 3.14)**	**<0.01**	**1.88 (1.19, 2.97)**	**<0.01**

Abbreviation: BMI-SDS= body mass index-standard deviation scores; 95%CI=95% confidence interval; OWOB=overweight/obesity; β=estimates; OR=odd ratios.

[α]: The adjusted models were adjusted for child ethnic background, maternal age and birth weight.

[β]: The highest completed education level was classified into two categories: (1) low (no education, primary school, lower vocational training, intermediate general school, or 3 years or less general secondary school); (2) high (>3 years general secondary school, intermediate vocational training, university or PhD degree, and higher vocational training). Social mobility was classified in three categories based on whether the highest completed education level of either the mother or the father changed upward, or stayed static from pregnancy to early childhood. The following categories of social mobility were defined: (1) static-high group (high to high); (2) static-low group (low to low) and (3) upward mobility group (low to high).

Discussion

In this study, we studied the association between parent education in pregnancy and in early childhood, as well as and changes in parent education between these two time points, and child weight status at age six and ten years. We explored the association for both maternal and paternal education level. Our results suggest that a low education level of the parent in pregnancy or early childhood is associated with a higher BMI-SDS or risk of OWOB of the child at both age six and ten. Our results also suggest that children from mothers with a static-high education level had lower BMI-SDS or risk of OWOB at both ages compared to children from mothers attaining a high education level in early childhood. Moreover, children from fathers with a static-low education level had higher BMI-SDS or risk of OWOB at both ages compared to children from fathers attaining a high education level in early childhood.

In line with previous research [3, 6, 7], our study showed that low parent education, either in pregnancy or early childhood, was associated with higher BMI-SDS and risk of OWOB at child age six and ten years. Both parents profoundly influence children's weight status and lifestyles through their own behaviors, parenting practices, and roles in shaping the common home environment of diet and physical activity [26]. Parents with high education level are more receptive to understand health-related knowledge, perform healthier parenting practices on children's health behaviors [27], such as less sedentary behaviors [13], more physical activity [11], healthier diet [12] and other obesity-related lifestyles. Meanwhile, higher parent education also increases family income, giving the more educated parents easier/quicker/better access to material resources [28]. Therefore, interventions on childhood obesity targeted to parents with low education level should be implemented from pregnancy onwards [29, 30].

Although social mobility has been well studied with regard to adulthood obesity [16-18], only few studies investigated the associations between social mobility and health outcomes in children's early life by considering and tracking the change in parent education [20, 22]. A study conducted in Brazil has tracked the change of parental SEP between early childhood (0-5 years) and adolescence (10-17 years) and childhood overweight in adolescence. They suggested that children from low educated parents who attained a high education level between early childhood and adolescence benefitted most in terms of lower risk of obesity (10-17 years) [20]. Another study in the US indicated positive associations between upward social mobility prior pregnancy and improved birth weight outcome [22]. This literature shows that the upward social mobility in early life can lead to better health outcomes in children [31].

In our study, we specifically focus on the upward social mobility regarding the change of parent education, and we found different results between mothers and fathers. In our study children from low-educated mothers who attained high education level during early childhood had a higher BMI-SDS and a higher risk of OWOB at child age six and ten years when compared to the children from mothers who already attained high education level during pregnancy. Low maternal education level might increase children's vulnerability to the cumulative nature of obesogenic factors due to the poorer use of positive parenting practices and enhanced acquisition of the familial and residential environment [3, 6, 7]. These disadvantages could outweigh the advantages of the increase in maternal education during early childhood. Since education is known to impact behavior, problem-solving capacity and value [32], it might take more time for mothers who attain a high education level to translate their new health knowledge into practice and behavior. Also, mothers who attained high education level after their child was born might be challenged to a higher extent to combine and find a balance between more work and families [14]. Therefore, mothers might be less involved in determining children's behaviors, particularly diet quality [33] and physical activities [11]. Finally, it is possible that the samples of mothers who attained higher education level and who had static low education level were too small to detect a difference with regard to childhood OWOB. Therefore, future studies with large sample size are warranted.

Currently, the role of paternal education level in childhood OWOB is underrepresented in published studies. Most studies used maternal education [3, 5-7] or combined both maternal and paternal education together [8-10] as a proxy of parent education. We observed that high paternal education level was associated with lower BMI-SDS and lower risk of OWOB for the child compared to of children of fathers with a static-low education level. Similar to our study, an international cross-sectional study indicated that the positive influence of parent education on childhood OWOB was stronger with fathers than with mothers in developed countries [34]. It should be noted that most of the existing childhood obesity treatment or prevention programs with parent involvement have not engaged fathers [26]. Therefore, our results also yield the importance to understand the role and presence of father education. More studies are needed to provide insight in the impact of father education and how fathers can best be involved in intervention studies.

In our study, we also found that the associations of maternal education level and childhood OWOB at child age ten years were more apparent in the Dutch population. We recommend research to study the relation between ethnic background, the social mobility and childhood OWOB.

Strengths of this study include the prospective cohort data with a follow-up period of up to ten years, the objective anthropometric measurements and, most importantly, the availability of the measures of parent education in both pregnancy and early childhood. However, several limitations should be well considered. First, the current study included a relatively high educated study population (Shown in **supplemental table 1**). As a result, the social mobility reported in our study, may be an underestimation of movement from lower to higher education level the changes at population level. Second, the decision to dichotomize parent education as either low or high could cause loss of information. However, it gained robust cell frequencies in order to perform reliable analyses. Third, we toned to be aware of confounding by unmeasured factors which is always apparent in epidemiological studies. Fourth, this study relied on self-report of parent education which is prone to measurement bias. Despite these methodological limitations, this study contributes to the existing knowledge on the differences of childhood OWOB in the process of intra-generational social mobility of their parents.

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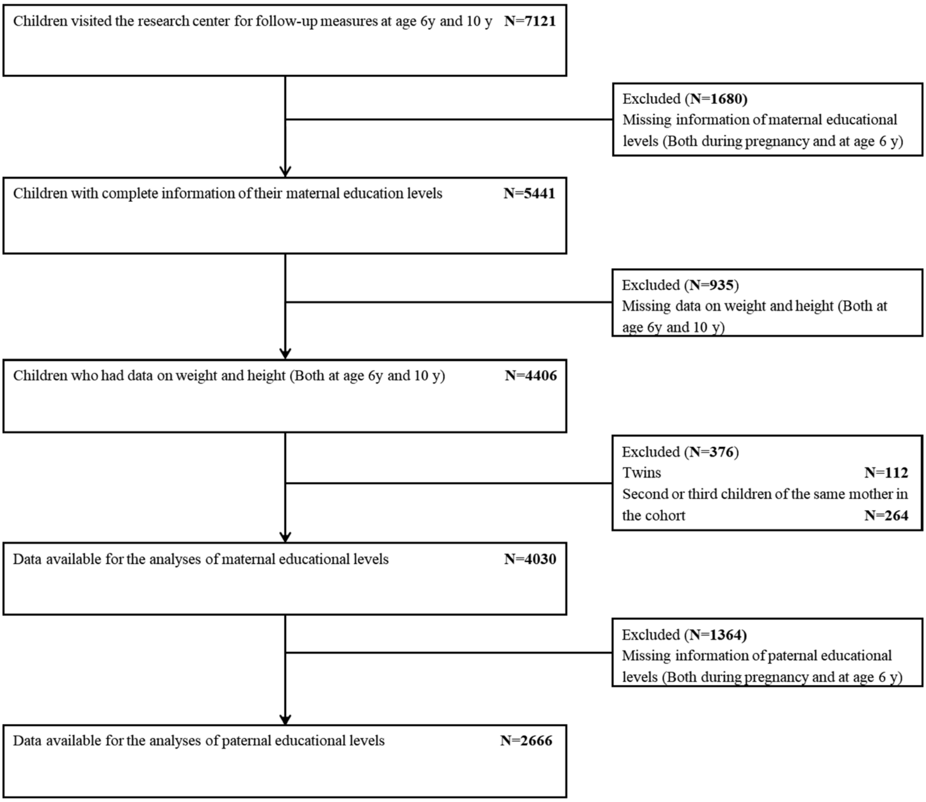

Supplemental Figure 1. Flowchart of participants included for analysis

Supplemental Table 1. Comparison between the included and excluded sample of the cohort [Mean (SD) or N (%)]

	Exclude (N=3091)	Included (N=4030)	Total (N=7121)	P value
Parental Characteristics				
Maternal age at enrollment (years)	29.59 (5.57)	31.24 (4.69)	30.52 (5.16)	< 0.01
Maternal education level in pregnancy				
High	1667 (69.2%)	3342 (82.9%)	5009 (77.8%)	< 0.01
Low	741 (30.8%)	688 (17.1%)	1429 (22.2%)	
Paternal education level in pregnancy				
High	1053 (75.2%)	2283 (81.4%)	3336 (79.4%)	< 0.01
Low	348 (24.8%)	520 (18.6%)	868 (20.6%)	
Children's Characteristics				
Birth weight (grams)	3360.24 (599.78)	3437.86 (551.90)	3404.22 (574.39)	< 0.01
Sex				0.61
boys	1554 (50.3%)	2002 (49.7%)	3556 (49.9%)	
girls	1536 (49.7%)	2028 (50.3%)	3564 (50.1%)	
Ethnic background				< 0.01
Dutch	1340 (46.7%)	2580 (64.0%)	3920 (56.8%)	
Other Western	235 (8.2%)	354 (8.8%)	589 (8.5%)	
Non-Western	1297 (45.2%)	1096 (27.2%)	2393 (34.7%)	

[α]: The highest completed education level was classified into two categories: (1) low (no education, primary school, lower vocational training, intermediate general school, or 3 years or less general secondary school); (2) high (>3 years general secondary school, intermediate vocational training, university or PhD degree, and higher vocational training).

Supplemental Table 2. The association of maternal education level with BMI-SDS and OWOB with OWOB at child age ten years stratified by child ethnic background [α]

Subgroups	Child ethnic background						$P_{interaction}$
	Dutch		Other Western		Non-Western		
	β/OR (95%CI)	*P*	β/OR (95%CI)	*P*	β/OR (95%CI)	*P*	
BMI-SDS measured at 10 y							
Maternal education level measured in pregnancy [β]							
High	Ref		Ref		Ref		**0.038**
Low	**0.52 (0.41 – 0.63)**	**<0.001**	0.30 (-0.08 – 0.67)	0.122	**0.26 (0.12 – 0.40)**	**<0.001**	
Maternal education level measured in early childhood [β]							
High	Ref		Ref		Ref		**0.020**
Low	**0.59 (0.43 – 0.74)**	**<0.001**	0.29 (-0.15 – 0.74)	0.194	**0.26 (0.10 – 0.42)**	**0.001**	
OWOB measured at 10 y							
Maternal education level measured in pregnancy [β]							
High	Ref		Ref		Ref		**0.001**
Low	**3.26 (2.41 – 4.43)**	**<0.001**	**2.38 (1.08 – 5.26)**	**0.032**	**1.50 (1.14 – 1.97)**	**0.004**	
Maternal education level measured in early childhood [β]							
High	Ref		Ref		Ref		**0.001**
Low	**3.59 (2.45 – 5.25)**	**<0.001**	**2.70 (1.09 – 6.71)**	**0.032**	**1.47 (1.09 – 1.98)**	**0.013**	

Supplemental Table 2. The association of maternal education level with BMI-SDS and OWOB with OWOB at child age ten years stratified by child ethnic background [α]

	Child ethnic background						
	Dutch		Other Western		Non-Western		
Subgroups	β/OR (95%CI)	*P*	β/OR (95%CI)	*P*	β/OR (95%CI)	*P*	$P_{interaction}$
OWOB measured at 10 y							
Social mobility measured by maternal education level[β]							
Upward mobility group	Ref		Ref		Ref		**0.004**
Static-high group	**0.38 (0.25 – 0.59)**	**<0.001**	0.61 (0.17 – 2.23)	0.451	0.71 (0.46 – 1.10)	0.122	
Static-low group	1.52 (0.90 – 2.58)	0.121	1.71 (0.39 – 7.57)	0.477	1.10 (0.68 – 1.76)	0.700	

Abbreviation: BMI-SDS= body mass index-standard deviation scores; 95%CI=95% confidence interval; OWOB=overweight/obesity; β=estimates; OR=odd ratios.

[α]: The adjusted models were adjusted for maternal age and birth weight.

[β]: The highest completed education level was classified into two categories: (1) low (no education, primary school, lower vocational training, intermediate general school, or 3 years or less general secondary school); (2) high (>3 years general secondary school, intermediate vocational training, university or PhD degree, and higher vocational training). Social mobility was classified in three categories based on whether the highest completed education level of either the mother or the father changed upward, or stayed static from pregnancy to early childhood. The following categories of social mobility were defined: (1) static-high group (high to high); (2) static-low group (low to low) and (3) upward mobility group (low to high).

CHAPTER 8

General discussion

Summary of findings

Social inequalities in children's lifestyle behaviors

The findings of the studies presented in this thesis show that the indicators of family SES are associated with the clustering of children's lifestyle behaviors in early childhood. **Chapter 2** describes the associations of family SES, measured by both maternal educational level and net household income, and the clustering of energy-related lifestyle behaviors. Based on four lifestyle behaviors (total screen time, physical activity, calorie-rich snacks consumption, and sugar-sweetened beverages consumption), three clusters were observed: "relatively healthy lifestyle", "high screen time and physically inactive", and "physically active, high snacks and sugary drinks". Children from high educated mothers or high-income households were more likely to be allocated in the "relatively healthy lifestyle" cluster, while children from low educated mothers or from low-income households were more likely to be allocated in the "high screen time and physically inactive" cluster.

These results demonstrate that children from families with a low SES tend to be assigned more often to clusters combining multiple unhealthy lifestyle behaviors. Parents with a high SES may be more inclined to use and adhere to information concerning healthy lifestyles and be more competent to offer healthy choices to their children compared to parents with a low SES [1]. Furthermore, lower maternal educational level, but not household income, was found to be associated with higher odds of being allocated in the "physically active, high snacks and sugary drinks" cluster. The educational level could reflect the level of parental knowledge on healthy lifestyle behaviors, which may impact the availability and opportunity for children to engage in healthy lifestyle behaviors [2]. This is especially relevant for young school-aged children, who spend relatively more time at home and are less affected by peer behavior, as compared to older school-aged children. Identifying the clustering of lifestyle behaviors in school-aged children is important since the lifestyle behaviors are established in early childhood and can track into later life [3, 4].

A systematic review showed that many studies investigating social inequalities in children's lifestyle behaviors follow a cross-sectional design [5]. The studies in this thesis underscore the added value of examining social inequalities in children's lifestyle behaviors, at a younger age, as well as in a longitudinal design. **Chapter 3** assessed the associations between family SES and repeatedly measured child television viewing time from children age 2 to 9 years. Results showed that television viewing time increases from age 2 to 9 years. In agreement with earlier studies [6-8], an independent inverse effect was found in maternal educational level with child television viewing time from preschool-age period to school-age period. However, the association was not found with regard to net household income at age 6 and 9 years. One possible explanation is that children who are in day-care, which may be more prevalent among families with a relatively high net household income, may spend less time watching television than children who are cared for at home [9]. After the first years (e.g. age 0-4 years in the Netherlands), almost all children, from both low and high income families, attend primary school. In longitudinal analyses, the television viewing trajectories differed significantly between children from high-, middle- and low-income households, but not between children of low-, mid-low-, mid-high- or high-educated mothers.

Chapter 4 assessed the associations between ethnic background and repeatedly measured child television viewing time from children age 2 to 9 years. Children with an ethnic minority background had greater odds of exceeding entertainment media guidelines (i.e. the guideline prescribes to have a child use media <1 hour/day). These results are in line with previous studies reporting ethnic inequalities in television viewing time in school-aged children [10, 11]. In addition to confirming results from these earlier studies, our study adds to the existing literature by showing that there was significant effect modification by maternal educational level on ethnic differences in television viewing time. In the high maternal educational level subgroup, the percentage of children watching television for more than 1 hour a day was significantly lower for the Dutch children than the children with other ethnic background. However, this difference was not statistically significant among children from low-educated mothers. It has been reported that parental attitude toward television viewing and home environment factors are associated with children's television viewing time [11]. We found that mothers from all subgroups regarding ethnic background watched more television than Dutch mothers at child age 4 years. Furthermore, children from all three non-Dutch ethnic groups more often had a television set in their bedrooms compared to children with a Dutch background. Only 2.0% of the children with a Dutch background had a television set in their bedroom at age 3 years; the highest percentage (17.5%) was found for children with a Moroccan background. At child age 9 years, 18.6% of children with a Dutch background had a television set in their bedroom; the highest percentage (34.2%) was found for children with a Surinamese background. It is therefore important to provide policymakers and researchers with information regarding the television viewing time of subgroups in the population. Interventions should take into account parents' cultural beliefs and values, as these may impact children's health-related behavior.

Overall, results of our studies indicate that social inequalities exist in children's lifestyle behaviors. Social inequalities in lifestyle behaviors are present at a young age and the trajectories of lifestyle behaviors may differ based upon the indicators of family SES. Healthcare practitioners need to be aware of the differences between subgroups in the population. Specific interventions can be developed to raise awareness among non-highly educated parents and/or parents with an ethnic minority background about the tracking of unhealthy lifestyle behaviors from childhood onwards, as well as the clustering of children's lifestyle behaviors.

Social inequalities in childhood health outcomes

Chapter 5 describes the associations between a wide range of sociodemographic factors (i.e. parental educational level, net household income, financial difficulties, parental employment status, and ethnic background) with current asthma and lung function among 10-year-old children. A systematic review reported that among young children, lower family SES, including lower maternal educational level, and higher poverty status, are associated with asthma [12]. However, among children aged 9 years and older, these associations were not observed [12]. Results from our study support this finding, as we also did not observe an inverse association between family SES and asthma at school-age after correcting for other sociodemographic factors. A possible explanation might be that when children grow older, they tend to spend more time at school or outside with their friends instead of staying at home. Thus, for example, the impact of poor housing conditions, which children from low SES families tend to be exposed to, maybe larger in early childhood than at later age [12, 13].

After adjustment for all other sociodemographic factors, children with a non-western ethnic background were significantly more likely to have current asthma, lower Forced Vital Capacity (FVC), higher FEV_1/FVC, and higher Forced Expiratory Flow after exhaling 75% of FVC (FEF_{75}). The higher risk of asthma among non-western children is not fully explained by low income or low educational level. A previous study showed that differences in asthma between subgroups with different ethnic background were independent of indicators of SES, and could only partly be explained by bad housing (e.g. houses infested with rodents, lacking sufficient heat) and neighborhood conditions (e.g. little/no social cohesion, boarded-up buildings nearby) [14]. Children with a non-western ethnic background had lower Forced Expiratory Volume in the first second (FEV_1) and FVC than their peers with a Dutch ethnic background. The relatively low in FEV_1 and FVC in children with a non-western ethnic background did not seem to reflect the presence of airway obstruction, as their FEV_1/FVC ratios and end-expiratory flows were not low, but were slightly higher. This may be due to reduced lung and airway size rather than obstruction. However, such smaller airways may represent a risk factor for asthma symptoms in children [15], which provides a possible explanation of differences in asthma between subgroups with different ethnic background. Another explanation could be the difference in the developmental age of puberty between populations [16, 17]. In childhood, FVC outgrows FEV_1, leading to falls in FEV_1/FVC; these trends are reversed in adolescence. Therefore, FEV_1/FVC ratios may be relatively higher among children who are relatively short for their age [17].

The findings described in this thesis add to the literature by showing that the association between ethnic background and current asthma at 10-years of age remains after adjustment for a wide range of family SES indicators. Furthermore, children with a non-western ethnic background were significantly more likely to have smaller lung volumes, but higher FEV_1/FVC and mid-expiratory flows.

Associations between the change in socioeconomic status and child health outcomes

The change in SES can pertain to various aspects such as the dynamics of family poverty status and the increase of parental educational level [18]. **Chapter 6** assessed the change of family poverty status from the mothers' pregnancy to child age 6 years, and its association with child weight status, asthma, and health-related quality of life (HRQoL). Net household income and the number of adults and children living from this income were measured at four time-points (during pregnancy, and at ages 2, 3 and 6). The presence of poverty was defined based on the equivalised household income being less than 60% of the median national income [19, 20]. Results showed that around ten percent of the children in our study were born into poverty. Previous studies have shown that poverty in early life is a sensitive period for poorer academic achievement [21], adolescent smoking [22], and adolescent overall health status [23]. Our results add to the evidence that poverty at birth is associated with a higher risk of overweight and obesity, and a lower physical HRQoL at early school-age. These associations were independent of the current family poverty status. Furthermore, the duration of poverty also plays an important role because the impact of poverty accumulates over time [24]. In chapter 6, 'chronic poverty' (i.e. 3–4 episodes of poverty among four time-points) was associated with higher odds of asthma, which is in line with several previous studies [25, 26]. Family stress has been reported to be more prevalent in families with 'chronic poverty' [27]. There is a considerable amount of literature indicating an association between child exposure to stress and the development of asthma [28-30]. These studies suggest that family stress may play a role in the pathway between chronic poverty and childhood asthma [28-30].

The relevance of change in SES for health has been well studied concerning adult obesity [31-33]. For example, adults with a static-low SES across the life course have a higher risk of ever having overweight or obesity compared to those who experienced upward change in SES or had a static-high SES [31-33]. C**hapter 7** reports on the associations between the variable "parents obtained a higher level of education between pregnancy and child age 6 years" (compared with parents having a "static-high" and a "static-low" education level), and the BMI-SDS score at age 6 years and 10 years. We observed that the subgroup children of fathers with a static-low education level had a higher BMI-SDS score at both 6 and 10 years in comparison with the subgroup children of fathers who attained a higher education level after the child was born. A low parental educational level might increase children's vulnerability to the cumulative nature of obesogenic factors due to the poorer use of positive parenting practices [34-36]. Attaining a higher education level after birth by the parents may be beneficial to attenuate the risk of their children developing overweight at school age. In our study this was illustrated with regard to the education level of the fathers, but not with regard to the education level of the mothers.

Overall, the changes in socioeconomic status (see chapter 6 and 7) were associated with various child health outcomes. Being born into poverty or experiencing multiple episodes of poverty may be associated with relatively more negative child health outcomes, such as being overweight, having asthma, or a lower HRQoL. Parents' obtaining a higher level of education after the child was born may be beneficial to attenuate the risk of the child developing overweight in late childhood. Knowledge regarding the development of family income and educational level from birth onwards may provide more information that is relevant for the study of various child health outcomes at different ages.

Methodological considerations

Study design

The studies described in this thesis are embedded in the Generation R Study, a population-based birth cohort study. First, cross-sectional studies were conducted in two chapters (Chapter 2 and 5) of this thesis. In Chapter 2, a cross-sectional study was conducted to study the association between SES and the clustering of child lifestyle behaviors in 6-year-old children. Evaluating the synergetic effect instead of the isolated effect of lifestyle behaviors helps to develop intervention targeting lifestyle behaviors simultaneously [37]. In Chapter 5, a cross-sectional study was conducted to study the association between SES and ethnic background with current asthma and indicators of lung function in 10-year-old children. However, causality between SES and children's lifestyle behaviors and health outcomes cannot be inferred with the use of a cross-sectional design in an observational study.

Second, longitudinal studies were conducted in four chapters of this thesis. In Chapter 3-4, longitudinal studies were conducted to study the associations between SES and ethnic background with child television viewing time. With the repeatedly measured child television viewing time from early childhood to the school period, the study design offers greater statistical power and the possibility to examine trends in child television viewing behavior over time. In Chapter 6, a longitudinal study was conducted to study the dynamics of family poverty status and child health at age 6 years. In Chapter 7, a longitudinal study was described studying the associations between the increase of parental educational level from mothers' pregnancy to child age 6 years and the occurrence of childhood overweight and obesity at age 6 and 10 years. The changes in SES in chapter 6 and 7 were captured with repeated measures on the SES indicators. In a life course perspective, the social inequalities in children's lifestyle behaviors and health outcomes develop over a long period. With the longitudinal design, repeatedly measured data can contribute to a better understanding of the issue at hand.

Study population

Loss to follow-up is considered as an important issue in any cohort study [38, 39]. In the Generation R Study, loss to follow-up during the first postnatal phase (0-4 years) and the school-age period was rather low and the general follow-up rates until the age of 10 years are around 80 % [40]. Non-response analyses in the separate studies presented in this thesis showed that data were more often missing for children from parents with a low educational level, a low household income, a family with financial difficulties, a mother or father without a paid job, or from a non-western ethnic background, indicating selective non-response. This may decrease the possibilities to perform an evaluation among specific subgroups, but not necessarily influence the associations under study [41].

Measurements

Socioeconomic status and ethnic background were the main exposures of interest in the studies presented in this thesis. The most common SES indicators, and those used in this thesis, include education, income, employment status, and financial difficulties [42-44]. Using multiple indicators of SES increases the ability to capture the variations in social inequalities as well as all dimensions of SES [42, 45]. In addition, in Chapter 6, the presence of poverty was derived from the self-reported household income and the number of adults and children in the household. Equivalised total household income (income/unit) was calculated, and poverty was defined based on the equivalised total household income of less than 60% of the median national income per unit according to the Organization for Economic Co-operation and Development (OECD) household equivalence scale [19, 20]. Increasing evidence showed particularly strong disadvantages for children from the lowest-income households [21, 46]. Thus, assessing the associations between the presence of poverty status and child health outcome may inform the development of social policies and intervention strategies to prevent and intervene with regard to family poverty (e.g. via welfare benefits, tax credits, etc.).

In this thesis, the parental country of birth plays a central role in the definition of child ethnic background. The definition was according to the standard methods used in the Netherlands, and as proposed by Statistics Netherlands [47], which implies that ethnic background is based on the migration background of the study population, not on their nationality and/or perceived ethnic identity. The advantage of this method is that it is objective and stable. A limitation of this definition is that people born in the same country might have different ethnic backgrounds, which cannot be distinguished [48]. Furthermore, this definition implies that 'third generation immigrants' were labeled as Dutch and were hence not distinguished.

Most of the data on child lifestyle behaviors collected in the studies presented in this thesis were derived from parent-reported questionnaires which could have led to response bias to some extent. For example, parents may have provided socially desirable answers (e.g. the over-reporting of favorable behaviors) [49]. Furthermore, recall bias is possible, such as parents may report inaccurate data because they cannot remember detailed frequency and duration/portion of each behavior.

Repeated measures are mostly common in longitudinal studies [50]. In Chapter 3 and 4, children's television viewing time was measured repeatedly at five-time points. These repeatedly-measured variables offer chances to examine trends in outcome variables [51]. In Chapter 6 and 7, the change in the SES was captured by repeatedly-measured poverty status and parental educational level. Repeatedly-measured exposures allow exploring the effect of the timing, accumulation, and change in family SES on child health outcomes. Information bias may have occurred due to the use of different items (e.g. net household income, number of adults and children in the household) in questionnaires at each age. However, our results showed that the percentage of people living in poverty in this study is comparable to that observed among the general population in the Netherlands [52, 53].

Analyses

Confounding and moderation
Confounding variables are variables that alter the association between exposure and outcome, but are not on the causal pathway [54]. When confounding variables are not taken into account, this may result in an underestimation or overestimation of the true association between exposure and outcome [54]. In the studies presented in this thesis, the potential confounders included were chosen based on previous literature. In Chapter 3 and 4, the 'change in coefficient' method was used to select the confounders for the analyses. With this method, confounders were included in the analyses when they lead to a substantial change in effect estimates (i.e. ≥10% change) [55]. Despite these efforts to adjust for confounding variables, residual confounding due to unmeasured or poorly measured variables cannot be ruled out [56-58].

Moderation happens when the size or direction of the association between the exposure on outcome varies according to a third variable. The third variable is known as the moderator [56]. For example, previous findings suggested that SES might moderate the association between ethnic background and health outcomes, and vice versa [59-61]. To assess the presence of effect modification, interaction terms between ethnic background and family SES were evaluated in the statistical models. If interaction effects were found, for example, in Chapter 3 the study was restricted to Dutch children only, or stratified analyses were conducted for different subgroups in Chapter 4. If no interaction effects were found, indicators of SES and ethnic background were included in the models simultaneously (Chapter 2, and 5-7). In these studies, associations between SES and the outcome variables were adjusted for ethnic background, and vice versa. Furthermore, in Chapter 3 and 4, the interaction effects between SES or ethnic background and child age were evaluated to assess whether social inequalities changed with the age of the child.

Missing data

Missing values can be handled in different ways, including complete case analysis, simple imputation, and multiple imputation [62]. When choosing the appropriate way to deal with the missing values in a study, the missing data mechanism has to be taken into account cause it may affect how much the missing data bias the results [62]. The missing data mechanism can be categorized into three classes: missing completely at random (MCAR), missing at random (MAR), and missing not at random (MNAR) [63, 64]. In Chapter 3, 4 and 6, a multiple imputation procedure was applied for missing in cofounding variables, and moderators. In Chapter 2, a multiple imputation procedure was also applied for missing values regarding the exposures. Five imputed datasets were generated using a fully conditional specified model, based on the relationships between all the variables included in the study [62]. Each dataset was analyzed separately and estimates were pooled to report the results. The use of the multiple imputation procedure can overcome the disadvantages of complete case analysis, which are loss of information, potential bias, and small confidence intervals [62].

Directions for future research

First of all, future research may benefit from improved measurements. In research on children's lifestyle behaviors (i.e. physical activity, calorie-rich snack consumptions, and sugar-sweetened beverages consumptions), diaries, activity trackers, or the Digital Photography of Foods Method can provide information in addition to parent-reported questionnaires [65, 66]. However, it should be noted that these methods are often time consuming and expensive, and therefore not always suitable for large cohort studies. Follow-up for certain subgroups with improved measurements embedded in the large cohort studies may benefit research.

In this thesis, the standard definition of Statistics Netherlands was used to establish the ethnic background of a person [47]. This definition captures the migration history and not nationality and/or perceived (ethnic) identity. People born in the same country may differ in culture and (ethnic) identity, which may determine their own and their children's lifestyle behavior [48, 67]. Future studies are recommended to take more components of ethnic background into account.

Second, the studies described in this thesis assessed social inequalities in lifestyle behaviors and health outcomes among young diverse children in a large city. Replication in other populations is warranted. As political, economic, and socio-cultural environment influences social inequalities [68], replication studies in similar countries, as well as countries with a different social system are recommended. In research on the clustering of children's lifestyle behaviors, a "physically active, high snacks and sugary drinks" cluster was found for the first time in children at this young age group. Further research is warranted to confirm the findings of this cluster in young school-aged children. Furthermore, our findings indicated that transition out of poverty before age 2 years was associated with a higher physical HRQoL and lower risk of asthma compared with children whose family remained in poor. This is in line with a previous study indicating that for those born into poverty, the odds of school readiness were higher only if children moved out of poverty before age 2 years [69]. These results emphasize the importance of supporting families with children who are born into poverty to transition out of poverty when the child is young. We recommend further studies to examine the impact of the timing of poverty change on child health outcomes.

Third, future research is needed to obtain more knowledge of the pathways underlying social inequalities in children's lifestyle behaviors and health outcomes. For example, parental attitudes and practices, child day-care attendance and availability of alternatives for screen time may explain the observed social inequalities in children's lifestyle behaviors and health [5, 70-74]. These potential explanatory mechanisms can differ at different ages [12, 70, 74]. In Chapter 5, after adjustment for all sociodemographic factors, inequalities in asthma among subgroups with different ethnic backgrounds were observed. Language barriers in care [75], suboptimal care [76], or asthma management [77] may further explain the observed inequalities, which deserves further study.

Finally, we recommend future research to follow children through adolescence and young adulthood. The social inequalities may vary according to different lifestyle behaviors and health outcomes, and also with the child's age [25]. Furthermore, the inequalities in early childhood lifestyle behaviors and health conditions may contribute to the adolescent's own socioeconomic status in later life. This relates to the so-called intergenerational transmission of socioeconomic status [68, 78]. Studies are needed to evaluate whether the observed inequalities in young children persist and how they progress over time.

Implications for policy and practice

In general, the studies presented in this thesis on social inequalities in children's lifestyle behaviors and health outcomes indicate that policies and interventions aiming to promote children's healthy lifestyle behaviors and child health in families with a low SES are highly warranted. Our findings suggest that prevention and intervention programs relevant are those that aim at the promotion of healthy lifestyle behaviors or improve the family SES itself (e.g. social benefit, grant for specific activity, early educational interventions) [79].

Lifestyle behaviors tend to cluster together, as was illustrated in this thesis. Intervention development and prevention strategies may target children's lifestyle behaviors simultaneously to promote healthy behaviors of children and their families. Research is needed to examine the possibilities to identify clustering of lifestyle behaviors in youth health care practice. Furthermore, parental behaviors and home environment situations offer opportunities for health promotion. The association between family SES and child television viewing time may be mediated by parental attitudes and practices (e.g. availability of media in the bedroom, screen time with parents) [5, 80]. Parental lifestyle behaviors may also play an important role in the pathway of social inequalities in children's television viewing time [11]. Future interventions should intensively involve parents and take into account their cultural beliefs and values [81].

Social policies may aim to improve people's access to education, employment [82]. Income policies may be used to (re)distribute the resources equally [82]. Access to resources such as knowledge, social support and benefits, and social networks enables individuals to minimize their risks to adopt unhealthy lifestyle behaviors [83]. Further, the results of our studies indicate that support for children whose families experience poverty early in life may be beneficial for health later in childhood. Early childhood education may improve later SES in adolescents from families with a low SES [84]. Short-term and long-term effects of early childhood education may include an increase in high school graduation, emotional self-regulation, and emotional development, and a decrease in crime and teen births [85-87]. Other relevant policies mentioned in the literature include the setting of minimum wages, college-admission policies, and good regulations for parenting leave [82].

General conclusions

The following conclusions can be drawn from the studies presented in this thesis. Social inequalities in the clustering of children's lifestyle behaviors (screen time, physical activity, calorie-rich snack, and sugar-sweetened beverages) are present among school-aged children. From preschool to school-age the trajectories of children's television time may vary according to indicators of social status. Findings also indicate that social inequalities in childhood asthma and indicators of lung function are present among school-aged children. Experiencing family poverty, either as an intermittent episode or as a chronic situation, is associated with childhood overweight, asthma, and HRQoL. When parents obtain a higher level of education after their child is born, this might be beneficial to attenuate the risk of the child developing overweight at school age. Our findings indicate that social inequalities in lifestyle behaviors and child health outcomes originate in early childhood and may accumulate over time, establishing an early base for social inequalities in later life. A joint effort between parents, schools, community, public health professionals, and policymakers is needed to reduce these inequalities.

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CHAPTER 9

Summary and Samenvatting

Summary

Inequalities in health studied in this thesis refer to differences in the health of individuals according to indicators of socioeconomic status (SES). Moreover, inequalities in health outcomes have been reported among individuals with different ethnic background. Children from families with a lower SES have poorer physical and mental health outcomes compared to children from families with a higher SES. Inequalities in child health are likely to emerge from the inequalities in lifestyle behaviors between children from families with a higher or lower SES or children from subgroups with a different ethnic background. Furthermore, the SES of a family may change over time. Studying the impact of changes in the level of the SES indicators on child health may contribute to understanding the social inequalities in child health. The main aim of this thesis was to study social inequalities in children's lifestyle behaviors and child overweight, asthma, and health-related quality of life (HRQoL). For this purpose, the following research questions were formulated:

Part one: Social inequalities in children's lifestyle behaviors

- Do clusters of energy-related lifestyle behaviors exist among children aged 6 years, and are the indicators of SES associated with the clusters of energy-related lifestyle behaviors?
- To what extent do social inequalities in child TV viewing time exist, and how do these inequalities change from child age 2 years to 9 years?
- To what extent do inequalities in child TV viewing time exist related to ethnic background, and how do these inequalities change from child age 2 years to 9 years?

Part two: Social inequalities in child health outcomes

- Are indicators of family SES and child ethnic background associated with childhood asthma and lung function in children aged 10 years?

Part three: Associations between the change in socioeconomic status over time and child health outcomes

- To what extent are the timing and the presence of family poverty from pregnancy to child age 6 years associated with child overweight, asthma, and HRQoL?
- To what extent is a change in parental educational level from pregnancy to child age 6 years associated with child weight status at child age 6 and 10 years?

The research questions were addressed by studies conducted within the Generation R Study, a population-based cohort study from fetal life until young adulthood, conducted in Rotterdam, the Netherlands.

The first part of the thesis focused on social inequalities in children's lifestyle behaviors. **Chapter 2** describes the associations of family SES, measured by both maternal educational level and net household income, and the clustering of energy-related lifestyle behaviors. Based on four lifestyle behaviors (total screen time, physical activity, calorie-rich snack consumptions, and sugar-sweetened beverages consumptions), three clusters were observed: "relatively healthy lifestyle", "high screen time and physically inactive", and "physically active, high snacks and sugary drinks". Children from high educated mothers or high-income households were more likely to be allocated in "relatively healthy lifestyle" cluster, while children from low educated mothers or low-income households were more likely to be allocated in the "high screen time and physically inactive" cluster.

Chapter 3 assessed the associations between family SES and repeatedly measured child television viewing time from child age 2 to 9 years. Results showed that for children in all the subgroups based on maternal educational level and net household income, television viewing time increases from age 2 to 9 years. Children of mothers with low educational level had a higher risk to exceed entertainment-media guidelines (i.e. the guideline prescribes to have a child use media <1 hour/day) at age 2, 3, 4, 6 and 9 years. The association was not found with regard to net household income at age 6 and 9 years. In longitudinal analyses, the interaction between net household income and child age was significant, indicating that the television viewing time trajectories were different between children from high-, middle- and low-income households. However the television viewing trajectories did not differ significantly between children of low-, mid-low-, mid-high- or high-educated mothers.

Chapter 4 describes the associations between ethnic background and repeatedly measured child television viewing time from child age 2 to 9 years in the Netherlands. The effect modification by family socioeconomic status was examined in cross-sectional and longitudinal analyses. Children with an ethnic minority background had greater odds to exceed entertainment media guidelines (i.e. the guideline prescribes to have a child use media <1 hour/day) at child age 2, 3, 4, 6 and 9 years. At the ages of 4 and 6 years, the associations between ethnic background and children's television viewing time were moderated by maternal educational level. In the high maternal educational level subgroup, the percentage of children watching television for more than 1 hour a day was significantly lower among Dutch children than among children with another ethnic background. For the low maternal educational level subgroup this difference was not statistically significant. In longitudinal analyses, television viewing trajectories differed among children with a different ethnic background. The disparities in trajectories were different for each maternal educational level.

In the second part of this thesis, social inequalities in child health outcomes were studied. **Chapter 5** describes the associations between a wide range of sociodemographic factors (i.e. parental educational level, net household income, financial difficulties, parental employment status, and child ethnic background) with current asthma and lung function among 10-year-old children. Current asthma (yes/no) was defined as ever doctor-diagnosed-asthma combined with wheezing symptoms or asthma-medication use in the past 12 months. Lung function was measured by spirometry, and included forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), FEV_1/FVC, and forced expiratory flow after exhaling 75% of FVC (FEF_{75}). When each sociodemographic factor was added to the model separately, low maternal educational level, low net household income, and the child having a non-western ethnic background were associated with higher chance of current asthma. After adjustment for all sociodemographic factors, an independent association was observed between child ethnic background and current asthma only. Children with a non-western ethnic background were significantly more likely to have higher risk of current asthma, smaller lung volumes (FVC), but higher FEV_1/FVC and mid-expiratory flows (FEF_{75}).

In the third part of this thesis, associations between a change in socioeconomic status over time and child health outcomes were evaluated. **Chapter 6** assessed the change of family poverty status from the mothers' pregnancy to child age 6 years, and its association with child weight status, asthma, and health-related quality of life (HRQoL). Poverty was defined based on the equivalised household income being less than 60% of the median national income. Results showed that poverty at birth was associated with an increased risk of overweight and obesity at age 6 years. Chronic poverty between mothers' pregnancy and child age 6 years (i.e. 3–4 episodes of poverty over four time-points) was associated with a higher risk of asthma. Both poverty at birth and chronic poverty were associated with lower physical HRQoL of the child.

Chapter 7 describes the associations between the variable "parents obtained a higher level of education between pregnancy and child age 6 years" (compared with parents having a "static-high" and a "static-low" education level), and the BMI-SDS score at age 6 years and 10 years. Results showed that the subgroup of children from fathers with a static-low education level had a higher BMI-SDS score at both 6 and 10 years in comparison with the subgroup of children from fathers who attained a higher education level after the child was born. When parents attain a higher education level after child birth, this may be beneficial to attenuate the risk of their children developing overweight at school age. In chapter 7 this was illustrated with regard to the education level of the fathers, but not with regard to the education level of the mothers.

The following conclusions can be drawn from the studies presented in this thesis. Social inequalities in the clustering of children's lifestyle behaviors (screen time, physical activity, calorie-rich snack, and sugar-sweetened beverages) are present among school-aged children. From preschool to school-age the trajectories of children's television time may vary according to indicators of social status. Findings also indicate that social inequalities in childhood asthma and indicators of lung function are present among school-aged children. Experiencing family poverty, either as an intermittent episode or as a chronic situation, is associated with childhood overweight, asthma, and HRQoL. When parents obtain a higher level of education after their child is born, this might be beneficial to attenuate the risk of the child developing overweight at school age. Our findings indicate that social inequalities in lifestyle behaviors and child health outcomes originate in early childhood and may accumulate over time, establishing an early base for social inequalities in later life. A joint effort between parents, schools, community, public health professionals, and policymakers is needed to reduce these inequalities.

Samenvatting

In dit proefschrift worden ongelijkheden in gezondheid bestudeerd. Deze ongelijkheden in gezondheid verwijzen naar verschillen in de gezondheid van individuen volgens indicatoren van sociaaleconomische status (SES). Daarnaast zijn er in de literatuur ongelijkheden in gezondheidsuitkomsten gerapporteerd tussen personen met verschillende etnische achtergronden. Kinderen uit gezinnen met een lagere SES hebben slechtere lichamelijke en geestelijke gezondheidsuitkomsten dan kinderen uit gezinnen met een hogere SES. Ongelijkheden in de gezondheid van kinderen komen waarschijnlijk voort uit de verschillen in leefstijlgedragingen tussen kinderen uit gezinnen met een hogere of lagere SES, of kinderen uit gezinnen met verschillende etnische achtergronden. Bovendien kan de SES van een gezin in de loop van de tijd veranderen. Het bestuderen van de impact van veranderingen van de SES-indicatoren op de gezondheid van kinderen kan bijdragen tot het beter begrijpen van de sociale ongelijkheden op het gebied van de gezondheid van kinderen. Het hoofddoel van dit proefschrift was het bestuderen van sociale ongelijkheden bij kinderen op het gebied van leefstijl, overgewicht, astma en kwaliteit van leven. Hiervoor zijn de volgende onderzoeksvragen geformuleerd:

Deel één: sociale ongelijkheden in de leefstijl van kinderen

- Bestaan er clusters van energie-gerelateerde leefstijlgedragingen bij kinderen van 6 jaar en zijn de indicatoren van SES geassocieerd met clusters van energie-gerelateerde leefstijlgedragingen?
- In welke mate zijn er sociale ongelijkheden in de televisiekijktijd van kinderen en hoe veranderen deze ongelijkheden in de leeftijd van 2 jaar tot 9 jaar?
- In welke mate bestaan er ongelijkheden in de televisiekijktijd van kinderen die gerelateerd zijn aan etnische achtergrond en hoe veranderen deze ongelijkheden van de leeftijd van 2 jaar tot 9 jaar?

Deel twee: sociale ongelijkheden in de gezondheidsuitkomsten van kinderen

- Zijn indicatoren van familie-SES en de etnische achtergrond van kinderen geassocieerd met astma en longfunctie bij kinderen van 10 jaar?

Deel drie: Associaties tussen de verandering in sociaaleconomische status in de tijd en de gezondheidsuitkomsten van kinderen

- In welke mate zijn de timing en de aanwezigheid van armoede in het gezin, vanaf de zwangerschap tot de leeftijd van zes jaar, geassocieerd met overgewicht, astma en kwaliteit van leven bij kinderen?
- In welke mate hangt een verandering in het opleidingsniveau van ouders tussen de zwangerschap naar de leeftijd van 6 jaar van het kind samen met het gewicht van het kind op 6 en 10 jaar?

De onderzoeksvragen werden beantwoord door studies uitgevoerd binnen de Generation R studie. De Generation R studie is een cohortstudie onder de bevolking van Rotterdam, Nederland, waarbij gezinnen worden gevolgd vanaf de zwangerschap van de moeder tot aan jong volwassenheid van het kind.

Het eerste deel van het proefschrift was gericht op sociale ongelijkheden in de leefstijlgedragingen van kinderen. **Hoofdstuk 2** beschrijft de associaties tussen SES van het gezin, aan de hand van het opleidingsniveau van de moeder en het netto gezinsinkomen, en de clustering van energie-gerelateerde leefstijlgedragingen. Op basis van vier leefstijlgedragingen (totale schermtijd, fysieke activiteit, calorierijke snackconsumpties en consumptie van suikerzoete dranken), werden drie clusters waargenomen: 'relatief gezonde leefstijl', 'veel schermtijd en lichamelijk inactief' en 'lichamelijk actief, veel snacks en suikerhoudende dranken'. Kinderen van hoogopgeleide moeders of huishoudens met een hoog inkomen behoorden vaker tot het cluster 'relatief gezonde leefstijl', terwijl kinderen van laagopgeleide moeders of huishoudens met een laag inkomen vaker behoorden tot het cluster 'veel schermtijd en lichamelijk inactief'.

Hoofdstuk 3 onderzocht de associaties tussen de SES van het gezin en de herhaaldelijk gemeten tijd dat kinderen televisie keken, van 2 tot 9 jaar. De resultaten toonden aan dat voor kinderen in alle subgroepen op basis van het opleidingsniveau van de moeder en het netto gezinsinkomen, de tijd dat kinderen televisie kijken toeneemt van 2 tot 9 jaar. Het opleidingsniveau van de moeder was tegengesteld gerelateerd aan het overschrijden van de richtlijnen voor entertainment-media (d.w.z. de richtlijn schrijft voor dat een kind media <1 uur / dag gebruikt) op de leeftijden van 2, 3, 4, 6 en 9 jaar. De associatie werd niet gevonden met betrekking tot het netto huishoudinkomen op de leeftijden 6 en 9 jaar. In longitudinale analyses was de interactie tussen het netto gezinsinkomen en de kinderleeftijd significant. Dit geeft aan dat kinderen uit huishoudens met een hoog, gemiddeld en laag inkomen verschillende 'televisiekijk-trajecten' hebben, of te wel patronen van meer of minder televisie kijken in de periode van 2 tot 9 jaar. De 'televisiekijktijd-trajecten' verschilden over de jaren heen niet significant tussen kinderen van laag-, middenlaag-, middenhoog- of hoogopgeleide moeders.

Hoofdstuk 4 beschrijft de associaties tussen etnische achtergrond en herhaaldelijk gemeten televisiekijktijd van kinderen van de leeftijd 2 jaar tot 9 jaar in Nederland. Ook werd een analyse van effectmodificatie door de sociaaleconomische status van het gezin onderzocht in cross-sectionele en longitudinale analyses. Kinderen afkomstig van een etnische minderheid hadden een grotere kans om de richtlijnen voor entertainmentmedia te overschrijden (d.w.z. de richtlijn schrijft voor dat een kind media <1 uur / dag gebruikt) op de leeftijd van 2, 3, 4, 6 en 9 jaar. Op de leeftijd van 4 en 6 jaar werden de associaties tussen etnische achtergrond en de televisiekijktijd van kinderen gemodereerd door het opleidingsniveau van de moeder. In de subgroep van kinderen van wie de moeder een hoog opleidingsniveau had, was het percentage kinderen dat meer dan 1 uur per dag televisie keek significant lager bij de Nederlandse kinderen dan bij kinderen met een andere etnische achtergrond. Dit verschil was niet statistisch significant bij kinderen van laagopgeleide moeders. In longitudinale analyses verschilden de 'televisiekijk-trajecten' over de jaren tussen de subgroepen van kinderen met een verschillende etnische achtergrond. Per etnische subgroep verschilde het traject eveneens tussen de opleidingsniveau van de moeders.

In het tweede deel van dit proefschrift werden sociale ongelijkheden in de gezondheidsuitkomsten van kinderen bestudeerd. **Hoofdstuk 5** beschrijft de associaties tussen een breed scala van sociaal-demografische factoren (d.w.z. opleidingsniveau van de ouders, netto gezinsinkomen, financiële moeilijkheden, werksituatie van de ouders en etnische achtergrond van het kind) en het hebben van astma en een aantal longfunctie-metingen bij 10-jarige kinderen. Of een kind op dat moment astma had (ja / nee) werd bepaald aan de hand van de vraag of astma ooit door een arts was gediagnosticeerd en of het kind in de afgelopen 12 maanden piepende ademhalingssymptomen had of gebruik maakte van astmamedicatie. De longfunctie van het kind werd gemeten door spirometrie. Hiermee werden drie uitkomsten bepaald: geforceerd expiratoir volume in 1 seconde (FEV1), geforceerde vitale capaciteit oftewel longvolume (FVC), FEV1 / FVC en geforceerde expiratoire flow na uitademing van 75% van longvolume (FEF75). Eerst werden in de analyses de sociaal-demografische factoren afzonderlijk aan het model werd toegevoegd. In die analyses bleken een laag opleidingsniveau van de moeder, een laag netto huishoudinkomen en een niet-westerse etnische achtergrond geassocieerd met een grotere kans op astma bij het kind. Na correctie voor alle sociaal-demografische factoren in hetzelfde model werd alleen een onafhankelijk verband waargenomen tussen de etnische achtergrond van het kind en het hebben van astma als kind. Ook hadden kinderen met een niet-westerse etnische achtergrond significant meer kans op het hebben van astma en kleinere longvolumes (FVC). Echter deze groep kinderen had ook meer kans op een hogere FEV1 / FVC waarde en hogere geforceerde expiratoire flow na uitademing van 75% van het longvolume (FEF75).

In het derde deel van dit proefschrift werden associaties tussen een verandering in sociaaleconomische status in de loop van de tijd en de gezondheidsuitkomsten van kinderen geëvalueerd. **Hoofdstuk 6** onderzocht of veranderingen in het aldaar niet leven in armoede van een gezin, gemeten vanaf de zwangerschap van de moeder tot de leeftijd van 6 jaar van het kind, verband heeft met het gewicht, het hebben van astma en de kwaliteit van leven van het kind. Armoede werd gedefinieerd op als gezinsinkomen (gecorrigeerd voor het aantal gezinsleden), minder dan 60% van het mediaan nationaal inkomen. De resultaten toonden aan dat armoede in het gezin ten tijde van de geboorte van het kind was geassocieerd met een verhoogd risico op overgewicht en obesitas voor het kind op de leeftijd van 6 jaar. Aanhoudende armoede vanaf de zwangerschap van de moeder tot het kind 6 jaar was (d.w.z. deze gezinnen ervaarden 3 tot 4 periodes van armoede op vier momenten) ging gepaard met een hoger risico op astma voor het kind.

Zowel armoede bij de geboorte van het kind als chronische armoede werden in verband gebracht met een lagere fysieke kwaliteit van leven van het kind.

Hoofdstuk 7 bestudeert de associaties tussen veranderingen in het opleidingsniveau van de ouders en de Body Mass Index (BMI) van het kind op 6 en 10 jarige leeftijd. In deze studie werd gekeken naar opleidingsniveau van de ouders op het moment van de zwangerschap van de moeder en het opleidingsniveau van de ouders wanneer het kind 6 jaar oud was. Aan de hand van deze twee momenten werden ouders verdeeld in een nieuwe variabele met drie subgroepen: statisch laag opleidingsniveau, statisch hoog opleidingsniveau, of verkrijgen van een hoger opleidingsniveau. Uit de analyses kwam naar voren dat de subgroep kinderen van vaders met een statisch laag opleidingsniveau een hogere gestandaardiseerde BMI-score hadden op zowel 6 als 10 jarige leeftijd in vergelijking met de subgroep kinderen van vaders die een hoger opleidingsniveau hadden verkregen na de geboorte van het kind. Het verkrijgen van een hoger opleidingsniveau na de geboorte door de ouders kan gunstig zijn om het risico van overgewicht bij hun kinderen op schoolleeftijd te verkleinen. In hoofdstuk 7 werd dit geïllustreerd met betrekking tot het opleidingsniveau van de vaders, maar niet met betrekking tot het opleidingsniveau van de moeders.

De volgende conclusies kunnen worden getrokken uit de onderzoeken die in dit proefschrift worden gepresenteerd. Onder schoolgaande kinderen zijn er sociale ongelijkheden in de clustering van de leefstijlgedragingen (schermtijd, fysieke activiteit, calorierijke snacks en met suiker gezoete dranken). Hoeveel televisie kinderen kijken over de periode van voorschoolse leeftijd tot schoolgaande leeftijd varieert en hierin zijn sociale ongelijkheden te zien. Ook met betrekking tot de kans op astma als kind en indicatoren van de longfunctie bij schoolgaande kinderen blijken sociale ongelijkheden een rol te spelen.

Armoede in een gezin, zowel een korte episode als langdurige situatie, houdt verband met de kans dat een kind overgewicht of astma krijgt en de kwaliteit van leven die het kind heeft. Het behalen van een hoger opleidingsniveau door ouders nadat het kind is geboren kan gunstig zijn om het risico te verkleinen dat het kind in de late kinderjaren overgewicht krijgt.

De bevindingen geven aan dat sociale ongelijkheden in leefstijl en de gezondheidsuitkomsten van kinderen hun oorsprong hebben in de vroege kinderjaren en zich in de loop van de tijd kunnen opstapelen, waardoor een vroege basis wordt gelegd voor sociale ongelijkheden op latere leeftijd. Om deze ongelijkheden te verminderen is een gezamenlijke inspanning nodig van ouders, scholen, de gemeenschap, professionals werkzaam in public health en beleidsmakers.

APPENDICES

List of publications

Yang-Huang J, van Grieken A, Wang L, Jansen W, Raat H. Clustering of Sedentary Behaviours, Physical Activity, and Energy-Dense Food Intake in Six-Year-Old Children: Associations with Family Socioeconomic Status. *Nutrients* 2020;12(6). *(This thesis)*

Yang-Huang J, van Grieken A, van Meel ER, He H, de Jongste JC, Duijts L, Raat H. Sociodemographic factors, current asthma and lung function in an urban child population. *European Journal of Clinical Investigation* 2020:e13277. *(This thesis)*

Yang-Huang J, van Grieken A, Moll HA, Jaddoe VWV, Wijtzes AI, Raat H. Socioeconomic differences in children's television viewing trajectory: A population-based prospective cohort study. *PLoS One* 2017;12(12):e0188363. *(This thesis)*

Yang-Huang J, van Grieken A, Wang L, Jaddoe VWV, Jansen W, Raat H. Ethnic background and children's television viewing trajectories: the Generation R Study. *PLoS One* 2018;13(12):e0209375. *(This thesis)*

Rodriguez-Ayllon M, Derks IPM, van den Dries MA, Esteban-Cornejo I, Labrecque JA, **Yang-Huang J**, Raat H, Vernooij MW, White T, Ortega FB, Tiemeier H, Muetzel RL. Associations of physical activity and screen time with white matter microstructure in children from the general population. *NueroImage* 2020;205:116258.

Enthoven CA, Tideman JWL, Polling JR, **Yang-Huang J**, Raat H, Klaver CCW. The impact of computer use on myopia development in childhood: The Generation R study. *Preventive Medicine* 2020;132:105988.

Wang L, van Grieken A, **Yang-Huang J**, Vlasblom E, L'Hoir MP, Boere-Boonekamp MM, Raat H. Relationship between socioeconomic status and weight gain during infancy: The BeeBOFT study. *PLoS One* 2018;13(11):e0205734.

Submitted

Yang-Huang J, van Grieken A, You Y, Jaddoe VWV, Steegers EA, Duijts L, Boelens M, Jansen W, Raat H. Family poverty dynamics and child health at age 6 years: the Generation R Study. *Submitted for publication.*

Lin L, **Yang-Huang J**, Wang H, Santos S, van Grieken A, Raat H. Social mobility by parent education and childhood overweight and obesity at age 6 and 10 years. *Submitted for publication.*

PhD Portfolio

Name PhD student	Junwen Yang
Departments	Public Health/Generation R Study Group
Research school	Netherlands Institute for Health Sciences (NIHES)
PhD period	September 2015-December 2020
Promotor	Prof. dr. Hein Raat
Co-promotor	Dr. Amy van Grieken

PhD training and other activities	Year	Workload (ECTS)
1. PhD training		
Courses		
Biostatistical Methods I: Basic Principles	2015	5.7
Systematic Literature Retrieval (in PubMed) - 1 & 2, Systematic Literature Retrieval in other databases and Endnote	2015	1.0
CPO-course: Patient Oriented Research	2016	0.3
Quality of Life Measurement	2016	0.9
Repeated Measurements	2016	1.7
Topics in Meta-analysis	2016	0.7
Principles of Genetic Epidemiology	2016	0.7
Joint Models for Longitudinal and Survival Data	2016	0.7
Causal Inference	2016	1.4
Causal Mediation Analysis	2016	1.4
Scientific Writing	2016	3.0
Scientific Integrity	2016	0.3
Basic Course on 'R'	2018	2.0
Dutch A1, A2.1, A2.2 & B1.1	2015-2017	2.0
Seminars and workshops		
Generation R Research meetings, Erasmus MC, the Netherlands	2015-2020	1.0
Generation R Maternal Child Health research meetings, Erasmus MC, the Netherlands	2015-2020	1.0
Seminars Department of Public Health, Erasmus MC, the Netherlands	2015-2020	1.0
Youth Health Care Section meetings, Erasmus MC, the Netherlands	2015-2020	1.0
Youth Health Care Section research meetings, Erasmus MC, the Netherlands	2017-2020	1.0
International workshop on the intergenerational transmission of health inequalities	2018	0.3

(Inter)national conferences and presentations		
Poster Presentation, 8th INRICH workshop and EPOCH day, Barcelona, Spain	2016	0.3
Poster Presentation, 9th INRICH workshop and EPOCH day, Ithaca, New York, USA	2017	0.3
Oral Presentation, Generation R Research meetings, Erasmus MC, the Netherlands	2019	0.3
Oral Presentations, Seminars Department of Public Health, Erasmus MC, the Netherlands	2017, 2019	0.7
Oral Presentation, the International Society of Behavioral Nutrition and Physical Activity (ISBNPA) 2019 Annual Meeting, Prague, the Czech Republic	2019	0.7
Oral Presentation, 20th EUSUHM Youth Health Care in Europe, Rotterdam, the Netherlands	2019	0.7

2. Other activities

Generation R General Tasks	2015-2018	3.0
Collaborating Researcher EPOCH (Elucidating Pathways of Child Health Inequalities: An International Perspective)	2015-2020	1.2

About the author

Junwen Yang was born on 26th September, 1987 in Shanghai, China. In 2006, she completed high school at No.2 High School of East China Normal University. In the same year, she started her Bachelor study with a major in Preventive Medicine at Fudan University. In 2011 she obtained her Bachelor degree in Medicine (with honors) and started a master program in Health Technology Assessment, also at Fudan University. In 2015, she obtained her Master degree in Social Medicine and Health (with honors). During her master study, she also worked as a guidance counselor at the department of Public Health of Fudan University. In September 2015, she started her PhD project at the Generation R Study Group and the Department of Public Health at Erasmus University Medical Center in Rotterdam, the Netherlands. Junwen received a scholarship from the China Scholarship Council (CSC) to perform her PhD project in the Netherlands. Currently, Junwen is working as a researcher at the Department of Public Health, Erasmus MC on projects related to social inequalities and cost-effectiveness evaluation.

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