# PUBLIC HEALTH AT THE LOCAL LEVEL

## Promoting child and adolescent health and well-being

MIRTE BOELENS

# Public health at the local level: Promoting child and adolescent health and well-being

Mirte Boelens

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# Public Health at the Local Level: Promoting Child and Adolescent Health and Well-being

Publieke gezondheid op lokaal niveau: het bevorderen van de gezondheid en het welzijn van kinderen en adolescenten

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# CONTENTS

# 1

# General introduction

## CHILD AND ADOLESCENT HEALTH AND WELL-BEING

In the United Nations "Convention on the Rights of the Child" countries have promised to protect the right of every child to a standard of living adequate for the child's physical, mental, spiritual, moral and social development.(1) Worldwide, there have been improvements in in the health of children and adolescents and declines in absolute poverty and between-country inequalities.(2) However, whereas communicable, nutritional or neonatal diseases have declined non-communicable diseases have not.(2-4) Also in European countries there still are several public health issues to be tackled.(5) The World Health Organization Europe has set out multiple priorities for improving child and adolescent health and well-being in European countries in their report that is called: "European Child and Adolescent Health Strategy 2015-2020".(5) Two of these priorities for public health issues will be studied in this thesis. These are mental health problems and reducing obesity and overweight by promoting healthy nutrition and physical activity. Moreover, in this report it is recognized that all children and adolescents should deserve good quality parenting, and that socioeconomic health inequalities in children and adolescents are also a public health issue.(5-7) Parenting and socioeconomic health inequalities will also be studied in this thesis. At last, this report emphasizes that adult diseases, health and well-being can be rooted in childhood or adolescence.(5)

## PUBLIC HEALTH FOR CHILD AND ADOLESCENT HEALTH AND WELL-BEING

Public Health is defined by Acheson and the World Health Organization as "the art and science of preventing disease, prolonging life and promoting health through the organized efforts of society".(8, 9) According to the Oxford Textbook of Public Health, public health is the process of mobilizing and engaging local, regional, national and international resources to assure the condition in which people can be healthy.(10) Until recently, public health mostly focused on treatment after onset of the disease or focused on reducing risk factors in adult life. However, evidence shows that promoting the health and well-being and reducing health inequalities of children and adolescents could reduce the onset, persistence or severity of overweight, obesity, mental health problems and socioeconomic health inequalities.(6, 7, 11, 12)

Health promotion is a key element of public health.(9, 13) Health promotion has been defined as the process of enabling people to increase control over, and to improve their health in the Ottawa Charter (1986).(14) One priority set out by the Ottawa Charter for health promotion is to create physically, and psychosocially supportive environments

for children and adolescents.(14, 15) Moreover, health promotion focuses on reducing differences in current health status ensuring equal opportunities and resources to enable all people to achieve their fullest health potential.(14) Health promotion can come in many forms such as interventions, policies or policy programs implemented at schools, sport clubs or other associations, in neighbourhoods, at home or individually. (14, 16)

Public health and health promotion can be employed at international, national, regional and local levels.(9) Particularly local governmental bodies such as municipalities play an increasingly important role in promoting the health and well-being and in reducing health inequalities of children and adolescents.(13, 17) To illustrate, under the Dutch Public Health Act and Youth Care Act, responsibility for public health, prevention and health promotion at a local level lies with the local governmental bodies (i.e. municipalities).(18, 19) Every four years, municipalities formulate a public health strategy for their area. Also in other countries such as the United Kingdom or Norway, the role of local governmental bodies is emphasized.(20-22) Local governmental bodies could stimulate change by reducing central influence and promoting local autonomy.(13) Another underlying reason that is recognized as to why local governmental bodies play an important role in public health, is that local governmental bodies usually have primary responsibility for planning and delivering many services that are crucial to addressing socioeconomic determinants of health such as education, transport, housing and urban planning.(13) Local governmental bodies are also often in a strong position to bring a wide variety of local actors or stakeholders around the table to stimulate action.(13)

## CHILD AND ADOLESCENT PUBLIC HEALTH ISSUES

### Reducing mental health problems and promoting mental well-being

Around 10-20% of children and adolescents experiences mental health problems.(6) Onset of mental health problems in later life usually occurs in childhood and adolescents.(23) Improving the mental well-being of children and adolescents could prevent or reduce the persistence or severity of mental health problems.(24) Mental health problems include but are not limited to anxiety, depression or attention-deficit hyperactivity disorder.(25) Mental health problems could develop due to many different risk factors including parental history of mental disorders, stressful life events, poor physical health, unhealthy lifestyle, family functioning, stress, migration and socioeconomic factors.(26, 27) However, mental health is not the mere absence of mental health problems. It is state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution

to the community".(28) Besides, reducing the risk, severity and persistence of mental health problems promoting mental-well-being is also important. Protective factors are thought to contribute to resilience (i.e. the way an individual adapts in a positive way).(29) Potential protective factors are physical activity, sufficient sleep, limited screen time, peer acceptance and organized activities. The role of socioeconomic status indicators and migrant status and the role of participating in organized activities on mental health in children and adolescents is studied in this thesis.(30-33)

## Reducing overweight and obesity and promoting a healthy lifestyle

Currently around one third of all children is overweight or obese.(34) Just as mental health problems, overweight and obesity in childhood has been shown to be associated with overweight or obesity in adulthood.(34) Of all children that are overweight and obese, more than 60% will be overweight or obese in adulthood.(34, 35) Overweight and obesity can lead to many chronic diseases in later life such as mental health problems, type 2 diabetes, hypertension and cardiovascular disease.(7) Overweight and obesity are mostly due to unhealthy lifestyles including high food and energy intake and low energy expenditure because of limited physical activity.(36) Such unhealthy lifestyles are often formed during childhood or adolescence. Promoting and facilitating healthy habits, such as drinking water instead of sugar-sweetened beverages or eating more vegetables and fruit instead of energy-dense foodstuffs could contribute to acquiring a healthy lifestyle and thereby reduce the risk of becoming overweight or obese.(37, 38)

## Promoting parental self-efficacy

Parents (or other primary caregivers) are fundamental for the health, well-being and development of their children.(39) Parental quality is impacted by many interacting factors on the parent (e.g. developmental history or personality), child (e.g. temperament) or socio-contextual level (e.g. marital relations, social network or work).(40) Previous research has already linked parenting-self-efficacy to parenting outcomes, child outcomes and to a lesser extent to parental psychological functioning.(41, 42) Parenting self-efficacy has been defined as beliefs or judgments a parent holds regarding their own capabilities to organize and execute a set of tasks related to parenting.(43, 44) Promoting parenting self-efficacy could thus have a positive impact on child well-being and child development. In this thesis, we studied factors associated with parenting self-efficacy. Understanding which determinants are related to parenting self-efficacy may provide useful insights for the development of effective parenting support interventions and ultimately improve the health, well-being and development of children.

### Reducing socioeconomic inequalities in health

Socioeconomic inequalities in health are health differences of children and adolescents according to different indicators of socioeconomic status.(45) Examples of indicators of socioeconomic status are parental income, parental occupation, parental educational level, financial difficulties in the household and material deprivation. Having a migrant status is closely related.(46, 47) Indicators of socioeconomic status capture aspects of the social standing of individuals or groups.(45) Socioeconomic inequalities have been found for many health outcomes and diseases.(46, 48-50)

Such inequalities have also been found to be associated with the risk of mental health problems, obesity and overweight.(51-55) Many of these inequalities in health emerge during childhood or adolescence.(17) Moreover, socioeconomic inequalities experienced during childhood or adolescence can result in health problems in adulthood.(48) Therefore, investing in reducing socioeconomic inequalities in children and adolescents holds much potential for future health and well-being.(17) Children and adolescents can experience socioeconomic inequalities at the individual and family level but also at neighbourhood level.(46) For example, if parents have a low income or experience material deprivation or financial difficulties this can reduce the affordability of sport club memberships or healthy food.(56-58) Also, stress experienced due to the parental financial situation could increase the risk of several health outcomes.(46) Parental education could affect health outcomes by health knowledge about a healthy diet, physical activity or health and disease in general. Parental education has also been found to be associated with social networks, and beliefs of parents and thereby influencing health outcomes.(46) Inequalities at the neighbourhood level can include the presence or absence of resources and services such as physical infrastructure, healthcare facilities, recreational and sport opportunities, fast-food outlets, stores with healthy foods, or ecological and environmental influences.(45, 59)

## RESEARCH FOR LOCAL HEALTH PROMOTION AND PUBLIC HEALTH

Local governmental bodies can play an important role in reducing mental health problems, overweight/obesity and socioeconomic inequalities in health and in promoting mental health, a healthy diet and physical activity by implementing preventive policies, policy programs or interventions. How exactly local public health can promote the health and well-being of children and adolescents relies partly on the available knowledge.(60) Research is important for designing and implementing effective interventions, policies and policy programs at the local level. First, research to the health, and well-being and to protective and risk and factors for certain health outcomes.(61) This allows us to

tailor interventions, policies and policy programs to certain target groups. This research also allows us to design what risk factors need to be targeted or what protective factors need to be emphasized or stimulated by interventions, policies and policy programs. Second, research evaluating the effectiveness, process of implementation, and effective elements of interventions, policies and policy programs is also needed.(60) Identifying effective elements of- and effective interventions, policies and policy programs can be used for the development or adjustment of interventions, policies and policy programs. Process evaluations are needed to understand the likelihood of implementation and to explain the effectiveness of an intervention, policy or policy program.(60)

The model of planned health education and promotion by Brug et al., is a model that can be used for the development of effective interventions, policies and policy programs (See. Figure 1).(62) The model of planned health education and promotion also serves as a framework for this thesis.

This model includes five separate steps for intervention, policy or policy program development, subsequently followed by evaluation. The first step consists of identifying which health problems need to be addressed. The second step consists of analysing risk factors for this health problem. Step three consists of identifying determinants or mediators of these risk factors. Step four consists of translating these determinants and mediators to goals, strategies and methods that can be integrated in an intervention or policy program. Step five consists of the implementation and dissemination of the intervention, policy or policy program.

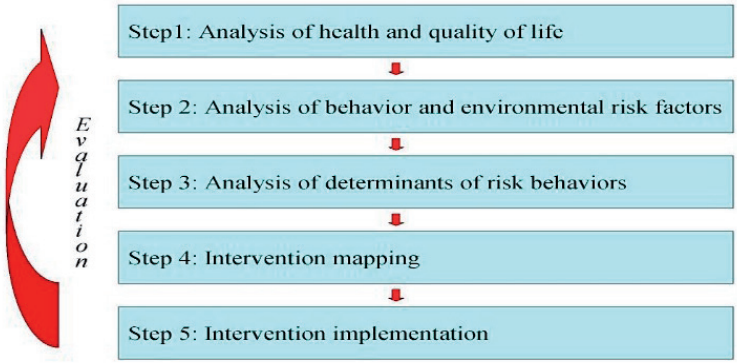


**Figure 1.** Model of planned health education and promotion.(62)

## AIM

The aim of this thesis was twofold. The first aim was to contribute to the knowledge of health and well-being of children and adolescents by studying health outcomes and their protective and risk factors. This aim also corresponds with the first three steps of the model of planned health education and promotion. The second aim was to contribute to the knowledge base of evidence-based interventions, policies and policy programs by evaluating local interventions and programs aimed to promote healthy lifestyles, health and well-being in children and adolescents. This aim corresponds to the fourth and fifth step, and the feedback-loop 'Evaluation' of the model of planned health education and promotion.

## FRAMEWORK OF THIS THESIS

As mentioned above, the aim of this thesis was addressed using guidance of the model of planned health education and promotion.(62) The first aim of this thesis corresponds to the first three steps of the model of planned health education and promotion. This aim is addressed in part 1: *Analysis of health, well-being, protective and risk factors.* In this part, there is a focus on identifying potential risk groups (i.e. populations at risk) for tailored or targeted interventions to promote mental health and vegetable/fruit consumption. In the first part there is also a focus on identifying potential protective or risk factors for mental health and parenting-self efficacy. The second aim of this thesis corresponds with step four and five and the continuous feedback loop of the model of planned health education and promotion. This aim is addressed in part 2: *Interventions and policy programs to promote healthy lifestyles, health and well-being. T*he effectiveness of interventions to promote water consumption among children of preschool and primary school-age is addressed in this part. In this part of the thesis, the design, methodology and effectiveness of a local collaborative community based programming approach aiming to increase the health, safety and talent development in youth and to reduce socioeconomic inequalities is also addressed. The research questions addressed in part 1 and 2 are:

### Part 1: Analysis of health, well-being, protective and risk factors

- What are the associations of multiple socioeconomic status indicators and migrant status with risk of a low vegetable and a low fruit consumption in 4- to 12-year old children?
- What are the associations of multiple socioeconomic status indicators and migrant status with risk of mental health problems in 4- to 12-year old children?

- What are the associations of organized sport activities and organized non-sport activities with mental health outcomes in children and adolescents based on published systematic reviews?
- What are the associations of participating in organized sport activities, organized non-sport activities and number of categories of organized activities with risk of mental health problems in a population-based sample of 4- to 12-year olds?
- What are the associations of factors on the parental, child and socio-contextual level with general parenting self-efficacy among parents with children aged 0- to 18 years?

### Part 2: Interventions and policy programs to promote healthy lifestyles, health and well-being

- What is the effectiveness of interventions to increase the consumption of water among children aged 2- to 12-years?
- What is the effectiveness of the Promising Neighbourhoods collaborative community-based program on health outcomes and on reducing socioeconomic inequalities in these outcomes?

## STUDIES AND DATA USED IN THIS THESIS

### The Rotterdam children's Public Health survey 2018

The Rotterdam children's Public Health survey 2018 is a cross-sectional survey administered by the municipal Health service of the city of Rotterdam (https://www.ggdrotterdamrijnmond.nl/wat-doet-de-ggd/onderzoek/). This survey is administered once every four years. This survey was held amongst parents of children living in Rotterdam aged 0-to 12-years-old. The survey consists of questions regarding the neighbourhood, general health, health behaviour, mental health, organized activities participation, stressful life events of children and the social networks, care use, socioeconomic status, migrant status, of parents and their children. It also comprises questions about parenting. **Chapter 2, 3, 5,** and **9** were conducted with data from this survey.

### Umbrella review organized activities

An umbrella review is a review that consists of previously published systematic reviews with or without meta-analysis. This umbrella review was about associations of organized activities on mental health outcomes in children and adolescents. The umbrella review protocol was registered in the PROSPERO register under register number CRD42020213597 on 9 November 2020 and is available via https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020213597. Systematic reviews that were published in English until March 25$^{th}$ 2021 (date last searched) were included. In total,

six systematic reviews were included in the umbrella review. **Chapter 4** was conducted using this data.

## Systematic reviews parenting self-efficacy and water consumption

A systematic review is a review that consists of previously published studies. For this thesis, two systematic reviews were conducted. The first systematic review was about associations of factors with general parenting-self efficacy. The systematic review protocol for this study was registered in the PROSPERO registry under registration number: CRD42019126737 on 20 June 2019 and is available via https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42019126737. For this systematic review, a systematic search was conducted for studies published in English until June 2020. In total 30 articles were included. **Chapter 6** was conducted using this data. The second systematic review was about the effectiveness of interventions to increase the consumption of water. The systematic review protocol for this study was registered in the PROSPERO registry under registration number CRD42019124808 on 18 April 2019 and is available via https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42019124808.
For this systematic review, studies published in English until 18 February 2019 were included. In total, 47 articles were included. **Chapter 7** was conducted using this data.

## Promising Neighbourhoods: A Local collaborative community based program

The Promising Neighbourhoods study is a mixed methods study and consists of a process and effect evaluation of a collaborative community-based program.(63) The study was carried out in six different neighbourhoods in Rotterdam. Three neighbourhoods were chosen as intervention neighbourhoods. In these neighbourhoods, the collaborative community based-programming approach was implemented. The other three control neighbourhoods were matched to these intervention neighbourhoods. No collaborative community-based program was implemented between 2018 and 2022 in these control neighbourhoods. For the effect evaluation of this program, two cross-sectional surveys were used. The first dataset is the Rotterdam children's Public Health Survey administered in 2018. This survey is the baseline measurement of this project. The survey was described above. For the Promising Neighbourhoods study, only data from children living in one of the six included intervention and control neighbourhoods were used. For the follow-up measurement, we administered a similar survey among parents of children aged 0- to 12-years-old living in these six neighbourhoods. For the effect evaluation, Difference-in-Difference logistic regression analysis was used.

The Promising Neighbourhoods collaborative community-based program is part of the youth policy 'Rotterdam is Growing'.(64) Aims of this program are to increase the health,

safety and talent development and to reduce socioeconomic inequalities in youth. The program is preventive and employs a local collaborative community-based programming approach. This includes collaborating with community stakeholders, data-based priority setting, knowledge-and theory-based policies and evidence-based interventions.

The collaborative community-based program that was implemented was managed by municipal district advisors.(65) Municipal district advisors are assigned to specific neighbourhoods. They coordinate and monitor the implementation of this program. The collaborative community program is tailored to the specific needs of each neighbourhood. It starts with an analysis of the needs of the neighbourhood. This is done using routinely collected data from different sources such as registry data of the municipality and Statistics Netherlands (CBS), police databases, survey data and routinely collected registration data by health professionals of the Child & Family Centres. Results of their analysis are discussed with stakeholders in the neighbourhood and complemented or amended based on their experiences. This is done to match the conclusions based on the quantitative data with the daily experiences of stakeholders and to gain local support by setting joint goals. After the needs-assessment, the municipal district advisors will assess the currently available measures, interventions, facilities and activities in the neighbourhood and check their presence in the so-called database Effective Youth Interventions (EYI) of the Netherlands Youth Institute (NYI). A detailed intervention-package is designed and implemented by the municipal district advisors. Interventions that are included in the EYI database are given priority. Finally, the municipal district advisors and stakeholders continuously monitor and revise the program. **Chapter 8** describes the design and methodology of this mixed-methods study and **chapter 9** includes and effect evaluation that was conducted with data from these surveys and within the Promising Neighbourhood research project.

## OUTLINE OF THIS THESIS

This thesis consists of 10 chapters and includes eight studies. See table 1 for an overview of the studies presented in this thesis. **Chapter 1** provides a general introduction for this thesis. This chapter also includes the aim, objectives and data or studies used for this thesis. After the general introduction, this thesis is divided in two parts corresponding with the aim of this thesis. The first part consists of **chapter 2, 3, 4, 5 and 6.** In **chapter 2 and 3,** associations of multiple socioeconomic status indicators and migrant status with risk of low vegetable and low fruit consumption and with risk of mental health problems in primary school-aged children was studied. In **chapter 4,** associations of

organized activities on different mental health outcomes in children and adolescents were examined. In **chapter 5,** associations of participating in organized sport activities, organized non-sport activities and number of categories of organized activities with risk of mental health problems of primary school-aged children was studied. In **chapter 6,**

**Table 1.** Overview of studies presented in this thesis.

| Chapter | Study design | Study/data | Sample | N | Research focus |
|---|---|---|---|---|---|
| *Part 1: Analysis of health, well-being protective and risk factors* | | | | | |
| **2** | Cross-sectional | The Rotterdam children's Public Health survey 2018 | Children aged 4- to 12-years-old living in Rotterdam | N=5,010 | To explore multiple associations of SES indicators and migrant status with low vegetable and/or fruit consumption. |
| **3** | Cross-sectional | The Rotterdam children's Public Health survey 2018 | Children aged 4-to 12-years-old living in Rotterdam | N=5,010 | To explore multiple associations of SES indicators and migrant status with risk of mental health problems. |
| **4** | Umbrella review | Five databases: Embase, MEDLINE Ovid, Web of Science, CINAHL EBSCOhost and PsycINFO Ovid) | Children and adolescents with a mean age between 0-to 21-years-old | 6 systematic reviews, 118 primary studies | To synthesize the evidence of associations of participation in organized activities (sport and non-sport) with mental health outcomes. |
| **5** | Cross-sectional | The Rotterdam children's Public Health survey 2018 | Children aged 4-to 12 years-old living in Rotterdam | N=4,957 | To study associations of participation in organized sport activities, organized non-sport activities and number of categories of organized activities with risk of mental health problems. |
| **6** | Systematic review | Four databases: PsycInfo Ovid, MEDLINE Ovid, EMBASE and Web of Science | Parents of children aged 0-18-years-ld | 30 studies | To synthesize the evidence of associations of parental, child and socio-contextual factors with parenting self-efficacy in parents with children aged 0- to 18-years-old. |
| *Part 2: Interventions and policy programs to promote healthy lifestyles, health and well-being* | | | | | |
| **7** | Systematic review & meta-analysis | 7 databases: (Embase, Medline Ovid, Web of Science, Cochrane, CINAHL EBSCOhost, PsycINFO Ovid and Google Scholar) | Children with a mean age between 2-to 12 years old at baseline | 42 studies in systematic review, 24 in meta-analysis | To synthesize the effectiveness of interventions to increase the consumption of water in children aged 2-to 12-years old. |

**Table 1.** Overview of studies presented in this thesis. (Continued)

| Chapter | Study design | Study/data | Sample | N | Research focus |
|---|---|---|---|---|---|
| **8** | Design paper | Promising Neighbourhoods | Children aged 0-18 years, neighbourhood network partners and key-leaders | NA | Evaluation design of the Promising Neighbourhoods project aimed to increase the health, safety and talent development and to reduce reducing socioeconomic inequalities using a collaborative community-based program tailored to specific neighbourhoods. |
| **9** | Effect analysis | Promising Neighbourhoods | Children aged 0-to 12-years-old living in Rotterdam | N=984 and N=413 | Effect evaluation of the Promising Neighbourhoods collaborative community-based program in 0-to 12-year-old children. |

associations of parental, child and socio-contextual factors with parental self-efficacy in parents with children of 0-to 18-year olds were examined. The second part consists of **chapter 7 and 8 and 9**. In **chapter 7,** the effectiveness of interventions to increase the water consumption of pre- and primary school-aged children was examined. In **chapter 8 and 9,** the design, methodology an effectiveness of a local collaborative community-based program that aims to increase the health, safety and talent development and to reduce socioeconomic inequalities in youth is described. Finally, in **chapter 10** the results of this thesis are summarized and critically appraised. In this chapter, methodological considerations, recommendations for future research and local public health are given.

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# Part 1

## Analysis of health, well-being, protective and risk factors

# 2

# Associations of socioeconomic status indicators and migrant status with low vegetable and fruit consumption in children

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## ABSTRACT

**Background:** It is important to provide insight in potential target groups for interventions to reduce socioeconomic inequalities in children's vegetable/fruit consumption. In earlier studies often single indicators of socioeconomic status (SES) or migrant status have been used. However, SES is a multidimensional concept and different indicators may measure different SES dimensions. Our objective is to explore multiple associations of SES indicators and migrant status with risk of a low vegetable/fruit consumption in a large multi-ethnic and socioeconomically diverse sample of children.

**Methods:** We included 5,010 parents of 4- to 12-year-olds from a Dutch public health survey administered in 2018. Cross-sectional associations of parental education, material deprivation, perceived financial difficulties, neighbourhood socioeconomic status (NSES) and migrant status with low (≤4 days a week) vegetable and fruit consumption in children were assessed using multilevel multivariable logistic regression models. Results are displayed as odds ratios (OR) with 95% confidence intervals (CI).

**Results:** Of the 4- to 12-year-olds, 22.1% had a low vegetable consumption and 11.9% a low fruit consumption. Low (OR 2.51; 95%CI: 2.05, 3.07) and intermediate (OR 1.83; 95%CI: 1.54, 2.17) parental education, material deprivation (OR 1.45; 95%CI: 1.19, 1.76), low NSES (OR 1.28; 95%CI: 1.04, 1.58) and a non-Western migrant status (OR 1.94; 95%CI: 1.66, 2.26) were associated with a higher risk of a low vegetable consumption. Low (OR 1.68; 95%CI: 1.31, 2.17) and intermediate (OR 1.39; 95%CI: 1.12, 1.72) parental education and material deprivation (OR 1.63; 95%CI: 1.27, 2.08) were also associated with a higher risk of a low fruit consumption.

**Conclusion:** Our findings indicate associations of multiple SES indicators and migrant status with a higher risk of a low vegetable/fruit consumption in children and thus help to identify potential target groups.

## INTRODUCTION

The consumption of sufficient vegetables and fruits during childhood is important for growth and development and influences health outcomes in later life(1, 2). Many children worldwide do not meet the recommendations for vegetable and fruit consumption(3). Socially disadvantaged children, especially, are at increased risk of not meeting these recommendations(4).

Socio-ecological models integrate the intrapersonal/individual, interpersonal, community, and organizational and public policy levels which interact and influence health behaviours(5-7). Public policies can improve dietary behaviour by targeting specific intrapersonal/individual characteristics, such as family socioeconomic status (SES) and neighbourhood socioeconomic status (NSES)(5-7). SES is a multidimensional concept that entails multiple related indicators(8). In the literature on health inequalities, family and neighbourhood indicators on income/poverty and educational level are measures that are often used(4, 8). Since ethnic minority groups are often disadvantaged groups, migrant status closely relates to SES indicators. Furthermore, migrant status may also be related to dietary behaviour because of cultural differences in food choices and patterns. Different SES indicators may measure different dimensions of SES(8). When aiming to identify possible target groups it is thus important to study associations of multiple SES indicators and migrant status with low vegetable and fruit consumption.

Previous research has reported associations of different SES indicators and migrant status with low vegetable and fruit consumption. Higher parental education has been associated with higher vegetable and fruit consumption in parents and their children(9). As such, parental education is hypothesized to be associated with parenting practices and knowledge about health benefits of vegetable and fruit consumption(10). Other SES indicators, such as material deprivation and perceived financial difficulties, may indicate the inability of parents to purchase sufficient vegetables and fruit for their children. Studies have demonstrated that children consume less vegetables and fruits if their parents reported difficulties in buying food or reported financial difficulties(11, 12). In multiple countries, energy-dense foods are cheaper than nutrient-dense foods(13). low-income groups often have more energy-dense diets lacking sufficient vegetables and fruits(13). Neighbourhoods with a low NSES may have less healthy food facilities and more unhealthy food facilities(14). It is hypothesized that this situation may lead to fewer vegetable and fruit purchases by parents(15, 16). Studies from the USA have shown that a child's migrant status may be associated with vegetable and fruit consumption in either direction(17, 18). It is suggested that this could possibly be due to differences in traditions, religion, beliefs, practices, food preferences and availability of

preferred foods. Also, acculturation and adoption of the diet of the host country might diminish diet-related cultural differences(17, 18). Integration is complex and depends on many aspects including but not limited to language, education, employment and accommodation. For example, integration could occur more easily in mixed communities (e.g. neighbourhoods) than in ghettos or ethnic enclaves with segregation(18, 19). This is also found in a study in which integration of Syrian refugees in Turkey was measured using cell phone data(20). The authors reported that in Istanbul, compared to touristic area's and to Anatolia, had a higher integration of Syrian refugees due to more mixed communities and more interaction with local inhabitants(20). Better integration and more communication between migrants and locals could lead to more acculturation such as adopting the diet of the host country(18).

Unfortunately, earlier studies that have studied associations of SES indicators and migrant status with low vegetable and fruit consumption in children often used a single indicator(4, 17, 21). As different SES indicators may measure different dimensions of SES it is important to study multiple SES indicators when examining possible target groups. Moreover, studies on migrant status are often from the USA, leading to findings that might not be directly comparable to European children due to differences in migration histories and host countries(17, 18, 21). Hence, we studied associations of multiple SES indicators (parental education, material deprivation, perceived financial difficulties, NSES) and migrant status with low vegetable and fruit consumption in a large, socioeconomically and ethnically diverse population-based sample of 4- to 12-year-olds living in the Netherlands.

## METHODS

### Study setting and participants

Data were obtained from a cross-sectional Dutch Public Health survey carried out in 2018 by the municipal public health service in the city of Rotterdam. A random probability sample of parents of 0- to 12-year-olds living in Rotterdam stratified by neighbourhood was invited to participate. Parents received invitation letters with information and login details for the online survey. Hardcopy questionnaires were available in Dutch, English, or Turkish, and were enclosed with both reminders. The main caregiver was invited to complete the questionnaire. Non-responders were contacted by telephone. If needed, help was offered by clarifying questions so parents were able to complete the questionnaire. Additional effort was made to target parents with Turkish and Moroccan backgrounds and residents of neighbourhoods with a low response.

The sample consists of N=5,010 parents/caregivers of 4- to 12-year-olds. The response rate was 34% and varied between 23%-54%, depending on the neighbourhood. Response rates did not differ by age or gender of the children.

These data were linked to the most recent data about the NSES (2017) provided by the Netherlands Institute of Social Research (SCP). NSES scores were matched to individual questionnaire data using the neighbourhood code (based on postal codes).

We compared children with complete data (N=3,946) to children with one or more missing data (N=1,064). Children with missing data more often have higher educated parents, no material deprivation, more often lived in neighbourhoods with low NSES and with a Western migrant status ($p<0.01$), but did not show difference in age, gender, perceived financial difficulties, or vegetable and fruit consumption ($p>0.05$).

## Data Availability

The data underlying this article are provided by the municipal public health service in the city of Rotterdam and by the SCP. Data will be shared upon request to the corresponding author with the permission of the municipal public health service in the city of Rotterdam and the SCP.

## Measures on the family/individual level

### *Parental education*

Parental education was defined as the highest educational level obtained by either one of the parents. The main caregiver filled out the educational level of both parents on the questionnaire. Parental education was categorized as 'low education' (i.e. no education, primary school, or ≤4 years general secondary school),'intermediate education' (i.e. >4 years general secondary school or intermediate vocational training), and 'higher education' (i.e. higher vocational training, university degree, or higher) based on the Dutch Standard Classification of Education(22).

### *Material deprivation*

Eight statements assessed material deprivation (i.e. what parents cannot afford due to a lack of money). The statements resemble the EU-SILC (European Union Statistics on Income and Living Conditions) questions(23) but are targeted specifically at children: my child cannot:

1) be a member of a sports club,
2) be a member of another club such as theatre or music,
3) attend birthday parties or trips with school,

4) cannot go on holiday or days-out,
5) eat fruit or vegetables daily,
6) attend swimming lessons,
7) visit a care provider if that is actually necessary, and
8) receive the medication or care that is needed.

Answer categories were 'true', 'somewhat true', and 'not true'. We dichotomized the answers to 'yes' (true and somewhat true) and 'no' (not true). The answers to these eight statements resulted in a material deprivation score ranging from zero to eight (eight being the highest score i.e. parents could not afford any of the eight items). Internal consistency was good (Cronbach's alpha of 0.85). Due to a skewed distribution, the scale was dichotomized into 'no material deprivation', i.e. parents could afford all eight items, and 'material deprivation', i.e. parents could not afford one or more items.

***Perceived financial difficulties***

Perceived financial difficulties were assessed by the question "Have you had difficulties in the past twelve months making ends meet with your household income?", with answer categories: 'no', 'no but I do have to keep an eye on what I spend', 'yes some difficulty', and 'yes a lot of difficulty'. The answers were dichotomized as either: 'no' (answer categories 'no' and 'no but I do have to keep an eye on what I spend') or 'yes' (answer categories 'yes some difficulty' and 'yes a lot of difficulty').

***Migrant status***

Migrant status of the child was defined as 'Western migrant or Dutch' or 'non-Western migrant'. A non-Western migrant status was assigned when the child itself or either (or both) of the parents were born in a non-Western country(24).The Following countries were considered Western: Europe (except for Turkey), North America, Oceania, Indonesia and Japan(25). People from Indonesia and Japan are considered Western due to their socioeconomic and cultural position(25).

## Measure on the neighbourhood level

***Neighbourhood socioeconomic status***

The SCP computed NSES scores using principal component analysis based on registry data from 2017 on mean income, percentage low incomes, percentage low educated residents, and percentage unemployed residents in a neighbourhood(26). These NSES scores are standardized scores based on all other neighbourhoods in the Netherlands. These data were matched to the questionnaire data using the neighbourhood code (based on postal codes). In total, for 49 of the 57 neighbourhoods in our study NSES

could be matched. We dichotomized NSES to either a 'high' or a 'low' NSES using a median split.

## Study outcomes

### *Vegetable consumption*

Children's vegetable consumption was assessed using the following question: On how many days a week does your child eat vegetables? The question had eight answer categories:
'Almost never', 'one day', 'two days', 'three days', 'four days', 'five days', 'six days', and 'every day'. We dichotomized vegetable consumption as ≤4 days a week i.e. 'low' versus >4 days a week i.e. 'higher'. Higher vegetable consumption was used as the reference group.

### *Fruit consumption*

Children's fruit consumption was assessed using the following question: On how many days a week does your child eat fruit? The question had eight answer categories: 'Almost never', 'one day', 'two days', 'three days', 'four days', 'five days', 'six days', and 'every day'. We dichotomized fruit consumption as ≤4 days a week i.e. 'low' versus >4 days week i.e. 'higher'. Higher fruit consumption was used as the reference group.

## Confounders

Age, gender, and family situation of the child were considered confounders and derived from the public health survey(4, 8). Age was measured in years. Gender was measured dichotomously with 'boys' as the reference group. Family situation was dichotomized as either 'two-parent family' or 'single-parent/other family situation' with 'two-parent family' as the reference group.

## Statistical analyses

Normality of the data was inspected for the continuous variable age using the Kolmogorov-Smirnov test and was found to be not normally distributed ($p < 0.001$). Descriptive statistics (i.e. percentages for categorical variables and median with interquartile range (IQR) for age), chi-square and Mann-Whitney U tests were used to describe and compare children with a low or higher vegetable and fruit consumption. Further, we computed the percentage children with a low vegetable and a low fruit consumption in each low and high SES neighbourhood and presented this information on a map for (Figure 1 and Figure 2) for a visual inspection of the distribution.

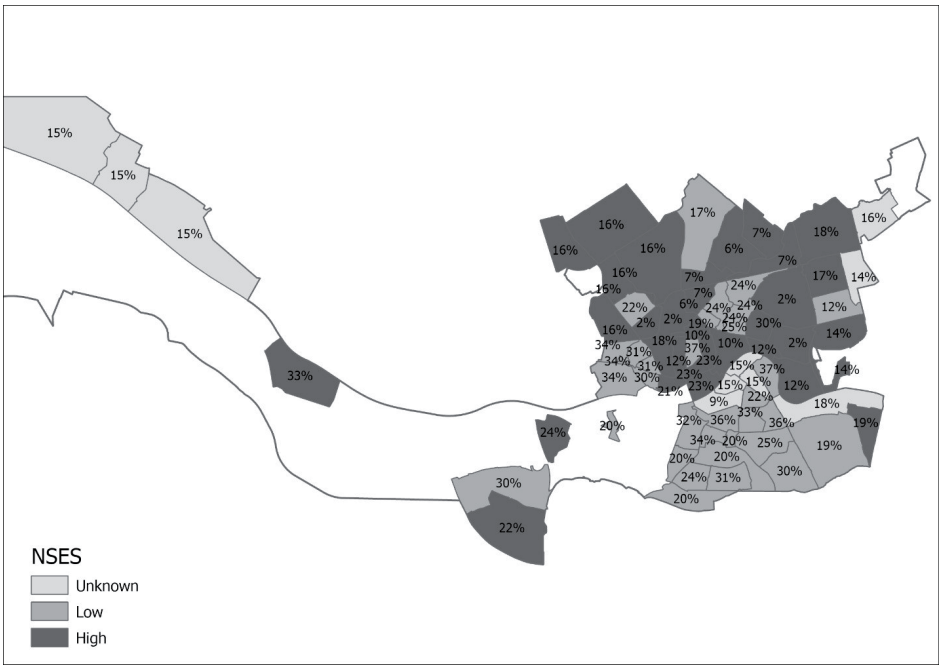


**Figure 1.** Distribution of a low vegetable consumption of children across neighbourhoods with a low or high neighbourhood socioeconomic status in Rotterdam in the Netherlands.
A low vegetable consumption was a vegetable consumption on ≤4 days per week. NSES=neighbourhood socioeconomic status.

Missing data (ranging between 0.2%-15.5%, see Table 1.) were imputed in SPSS using a fully conditional specified model based on the relationships between all the variables included in this study (M=10 datasets). Statistical analyses were performed on each of the imputed datasets and results were pooled using Rubin's Rules.

Associations of parental education, material deprivation, perceived financial difficulties, NSES and migrant status with low vegetable and fruit consumption in children were assessed using multilevel multivariable logistic regression analyses. A random intercept for neighbourhood and fixed slopes model was used to obtain the odds ratio (OR) and corresponding 95% confidence interval (CI) of the risk of low vegetable and fruit consumption. First, an intercept-only model was computed to obtain the median odds ratio (MOR). The MOR quantifies the magnitude of the variation in vegetable and fruit consumption that is explained by the neighbourhood level and varies between one (no variation) and infinity. Subsequently, three models were computed, i.e. crude models (unadjusted models containing one SES indicator or migrant status only), confounder


**Figure 2.** Distribution of a low fruit consumption of children across neighbourhoods with a low or high neighbourhood socioeconomic status in Rotterdam in the Netherlands.
A low fruit consumption was a fruit consumption on ≤4 days per week. NSES=neighbourhood socioeconomic status.

adjusted models, and full models adjusting for confounders and all other SES indicators and migrant status.

Interaction effects of sociodemographic variables (age, gender, and family situation) with SES indicators and migrant status were assessed by adding interaction terms one by one in the fully adjusted models. In a similar vein, interaction effects were investigated between all indicators of SES and migrant status. Bonferroni correction was applied for multiple testing when investigating the interaction effects (p=0.05/25=0.002). Multicollinearity was examined using Spearman's rho coefficients (all <0.7) and VIF values (all <3). Sensitivity analyses using the complete-case sample (N=3,946) and using non-daily vegetable and fruit consumption as outcome variables were performed.

All p-values were two-tailed and level of significance was set at 0.05. Statistical analyses were performed using IBM SPSS statistics for Windows, version 25.0 (International Business Machines Corporation, Armonk, New York).

# RESULTS

## General results

Table 1 presents characteristics of our study population. Daily vegetable and fruit consumption was reported for 46.5% and 65.5% of children, while a low consumption (≤4 days a week) was reported for 22.1% and 11.9%. Median age was 8.0 years (IQR= 6.0-10.0) and 48.4% were girls. The children who more often had a low vegetable and fruit consumption were boys or children from single-parent families (or other non-two parent families), from families with lower educated parents, from families with parents who experienced material deprivation or from families with parents who perceived financial difficulties ($p<0.05$). Furthermore, children from neighbourhoods with a low NSES more often had a low vegetable consumption ($p<0.05$). Figure 1 and 2 show the distribution of low and high SES neighbourhoods and the corresponding percentage of children with a low vegetable and fruit consumption. The percentage of children with a low vegetable consumption ranged from 2%- 27% depending on the neighbourhood. For fruit the percentage of children with a low consumption ranged between 2%-30%. Neighbourhoods with a low NSES were often in close proximity of other neighbourhoods with a low NSES and vice versa.

**Table 1.** Characteristics of the study population, total sample and subsamples according to vegetable and fruit. consumption.

| | | Vegetable consumption[1] | | | Fruit consumption[2] | | |
|---|---|---|---|---|---|---|---|
| | **Total sample** | **Higher (>4 days a week)** | **Low (≤4 days a week)** | **P-value** | **Higher (>4 days a week)** | **Low (≤4 days a week)** | **P-value** |
| **N, (%)** | 5,010 | 3,881 (77.9) | 1,099 (22.1) | | 4,405 (88.1) | 595 (11.9) | |
| **Age, median (IQR)** | 8.0 (6.0-10.0) | 8.0 (6.0-10.0) | 8.0 (6.0-10.0) | 0.336 | 7.0 (6.0-9.0) | 8.0 (7.0-10.0) | <0.001 |
| **gender, % (n)** | | | | 0.012 | | | 0.001 |
| Girl | 48.4 (2,426) | 79.5% (1,915) | 20.5 (495) | | 89.6 (2,167) | 10.4 (251) | |
| Boy | 51.6 (2,584) | 76.5% (1,966) | 23.5 (604) | | 86.7 (2,238) | 13.3 (344) | |
| **Family situation[3], % (n)** | | | | <0.001 | | | <0.001 |
| Single or other | 25.3 (1,256) | 74.1 (924) | 25.9 (323) | | 85.1 (1,066) | 14.9 (187) | |
| Two-parent | 74.7 (3,717) | 79.4 (2,936) | 20.6 (761) | | 89.2 (3,308) | 10.8 (402) | |

**Table 1.** Characteristics of the study population, total sample and subsamples according to vegetable and fruit. consumption. (Continued)

| | Total sample | Vegetable consumption[1] | | P-value | Fruit consumption[2] | | P-value |
|---|---|---|---|---|---|---|---|
| | | Higher (>4 days a week) | Low (≤4 days a week) | | Higher (>4 days a week) | Low (≤4 days a week) | |
| **Parental education[4], % (n)** | | | | <0.001 | | | <0.001 |
| Low | 16.6 (796) | 62.9 (498) | 37.1 (294) | | 82.5 (655) | 17.5 (139) | |
| Intermediate | 32.3 (1,554) | 72.3 (1,112) | 27.7 (425) | | 85.8 (1,330) | 14.2 (221) | |
| High | 51.1 (2,459) | 87.4 (3,751) | 12.6 (310) | | 91.7 (2,251) | 8.3 (204) | |
| **Material deprivation[5], % (n)** | | | | <0.001 | | | <0.001 |
| Yes | 22.1 (1,086) | 66.8 (721) | 33.2 (359) | | 82.7 (896) | 17.3 (187) | |
| No | 77.9 (3,828) | 81.5 (3,099) | 18.5 (705) | | 89.6 (3,425) | 10.4 (396) | |
| **Perceived financial difficulties[6], % (n)** | | | | <0.001 | | | <0.001 |
| Yes | 15.3 (756) | 66.9 (504) | 33.1 (249) | | 84.2 (635) | 15.8 (119) | |
| No | 84.7 (4,197) | 80.0 (3,337) | 20.0 (833) | | 88.8 (3,719) | 11.2 (470) | |
| **NSES[7], % (n)** | | | | <0.001 | | | 0.880 |
| Low | 55.0 (2,328) | 71.4 (1,652) | 28.6 (661) | | 87.6 (2,036) | 12.4 (288) | |
| High | 45.0 (1,907) | 83.2 (1,578) | 16.8 (319) | | 87.5 (1,666) | 12.5 (239) | |
| **Migrant status[8], % (n)** | | | | <0.001 | | | 0.006 |
| Non-Western | 41.1 (2,046) | 68.0 (1,380) | 32.0 (648) | | 86.6 (1,767) | 13.4 (274) | |
| Western | 58.9 (2,938) | 84.9 (2,485) | 15.1 (441) | | 89.1 (2,614) | 10.9 (319) | |

Study population consists of 4- to 12-year-olds (N=5,010) measured by a public health survey in 2018, the Netherlands. Percentages are row percentages for the stratified analyses and column for the total population. Statistical significance tested by Chi-square for categorical data and by Mann-Whitney U tests for continuous data. NSES=Neighbourhood Socio-economic Status; [1] 30 are missing (0.6%); [2] 10 are missing (0.2%); [3] 37 are missing (0.7%); [4] 201 are missing (4%); [5] 96 are missing (1.9%); [6] 57 are missing (1.1%); [7]775 are missing (15.5%); [8]26 are missing (0.5%).

## Vegetable consumption

Table 2 shows the results of the regression analyses for a low vegetable consumption. The MOR for vegetable consumption in children in the intercept-only model is 1.66, indicating neighbourhood variance in vegetable consumption. Low (OR 2.51; 95%CI 2.05, 3.07) and intermediate parental education (OR 1.83; 95%CI: 1.54, 2.17), material deprivation (OR 1.45; 95%CI: 1.19, 1.76) a low NSES (OR 1.28 95%CI: 1.04, 1.58) and a non-Western migrant status (OR 1.94; 95%CI: 1.66, 2.26) were associated with low vegetable consumption. Perceived financial difficulties were not associated with low vegetable consumption.

**Table 2.** Associations of SES indicators and migrant status with low vegetable consumption in N=5,010 4- to 12-year-olds.

| | Null model OR (95% CI) | Model 1 OR (95% CI) | Model 2 OR (95% CI) | Model 3 OR (95% CI) |
|---|---|---|---|---|
| | | Separate models | | Combined model |
| **Parental education** | | | | |
| Low | | **3.18 (2.62, 3.84)** | **3.17 (2.61, 3.86)** | **2.51 (2.05, 3.07)** |
| Intermediate | | **2.15 (1.82, 2.53)** | **2.15 (1.82, 2.54)** | **1.83 (1.54, 2.17)** |
| Higher | | Ref | Ref | Ref |
| **Material deprivation** | | | | |
| Yes | | **1.97 (1.69, 2.30)** | **1.96 (1.68, 2.29)** | **1.45 (1.19, 1.76)** |
| No | | Ref | Ref | Ref |
| **Perceived financial difficulties** | | | | |
| Yes | | **1.75 (1.48, 2.08)** | **1.72 (1.44, 2.06)** | 1.16 (0.93, 1.45) |
| No | | Ref | Ref | Ref |
| **NSES** | | | | |
| Low | | **1.87 (1.48, 2.35)** | **1.84 (1.46, 2.31)** | **1.28 (1.04, 1.58)** |
| High | | Ref | Ref | Ref |
| **Migrant status** | | | | |
| Non-Western | | **2.46 (2.12, 2.85)** | **2.44 (2.10, 2.83)** | **1.94 (1.66, 2.26)** |
| Western | | Ref | Ref | Ref |
| **MOR** | 1.66 | | | 1.31 |

Study population consists of 4- to 12-year-olds (N=5,010) measured by a public health survey in 2018, the Netherlands. Low vegetable consumption indicates a consumption on ≤4 days a week. SES=Socioeconomic Status; OR=Odds Ratio; CI=Confidence interval; NSES=Neighbourhood Socioeconomic Status; MOR=Median Odds Ratio (exp(sqrt(2*variance random intercept)*0.6745)); Numbers in **bold** indicate significance (P <0.05) Null model=intercept only; model 1 is a crude, unadjusted model; model 2 is adjusted for the age, gender (boy=ref) and family situation of the child (two-parent family=ref); model 3 is model 2 and additionally adjusted for all indicators of socioeconomic status and migrant status.

## Fruit consumption

Table 3 shows the results of the regression analyses for low fruit consumption. The MOR in the intercept-only model for fruit consumption in children is 1.58, indicating neighbourhood variance in fruit consumption. Low (OR 1.68; 95%CI: 1.31, 2.17) and intermediate parental education (OR 1.39; 95%CI: 1.12, 1.72) and material deprivation (OR 1.63; 95%CI: 1.27, 2.08) were associated with low fruit consumption. Perceived financial difficulties, NSES and migrant status were not associated with low fruit consumption.

**Table 3.** Associations of SES indicators and migrant status with low fruit consumption in N=5,010 4- to 12-year-olds.

| | Null model OR (95% CI) | Model 1 OR (95% CI) | Model 2 OR (95% CI) | Model 3 OR (95% CI) |
|---|---|---|---|---|
| | | Separate models | | Combined model |
| **Parental education** | | | | |
| Low | | **2.05 (1.62, 2.60)** | **1.84 (1.44, 2.34)** | **1.68 (1.31, 2.17)** |
| Intermediate | | **1.55 (1.26, 1.90)** | **1.49 (1.21, 1.83)** | **1.39 (1.12, 1.72)** |
| Higher | | Ref | Ref | Ref |
| **Material deprivation** | | | | |
| Yes | | **1.75 (1.45, 2.12)** | **1.69 (1.39, 2.06)** | **1.63 (1.27, 2.08 )** |
| No | | Ref | Ref | Ref |
| **Perceived financial difficulties** | | | | |
| Yes | | **1.41 (1.13, 1.76)** | **1.33 (1.06, 1.67)** | 0.90 (0.68, 1.19) |
| No | | Ref | Ref | Ref |
| **NSES** | | | | |
| Low | | 1.19 (0.90, 1.58) | 1.15 (0.86, 1.53) | 0.96 (0.72, 1.28) |
| High | | Ref | Ref | Ref |
| **Migrant status** | | | | |
| Non-Western | | **1.36 (1.13, 1.64)** | **1.29 (1.07, 1.56)** | 1.11 (0.91, 1.35) |
| Western | | Ref | Ref | Ref |
| **MOR** | 1.58 | | | 1.54 |

Study population consists of 4- to 12-year-olds (N=5,010) measured by a public health survey in 2018, the Netherlands. Low fruit consumption indicates a consumption on ≤4 days a week. SES=Socioeconomic Status; OR=Odds Ratio; CI=Confidence interval; NSES=Neighbourhood Socioeconomic Status; MOR=Median Odds Ratio (exp(sqrt(2*variance random intercept)*0.6745)); Numbers in **bold** indicate significance (P <0.05) Null model=intercept only; model 1 is a crude, unadjusted model; model 2 is adjusted for age, gender (boy=ref) and family situation of the child (two-parent family=ref); model 3 is model 2 and additionally adjusted for all indicators of socioeconomic status and migrant status.

### Additional analyses

We found no significant interaction effects (Supplemental Table 1).

### Sensitivity analyses

Sensitivity analyses using non-daily vegetable and fruit consumption as outcome variables were similar but NSES and migrant status were not associated with vegetable consumption and low parental education was not associated with fruit consumption (Supplemental Tables 2 and 3). Sensitivity analyses using a complete-case sample yielded similar results (Supplemental Tables 4 and 5).

## DISCUSSION

In this large socioeconomically and ethnically diverse population-based sample of 4- to 12-year-olds, we observed that having low/intermediate educated parents, parents who experience material deprivation, being from a low NSES neighbourhood and having a non-Western migrant status is associated with a higher risk of a low vegetable consumption. Furthermore, having low/intermediate educated parents or having parents who experience material deprivation is associated with a higher risk of a low fruit consumption.

We found that, in our sample, 22.1% had a low vegetable consumption. Of all children, 11.9% had a low fruit consumption. The low vegetable and fruit consumption is comparable to findings in other studies among European children(1, 27, 28).

We observed associations of low/intermediate parental education with low vegetable and fruit consumption in children. This is in line with previous research among European 4- to 11-year-olds(29). In previous research it has been observed that parental vegetable/fruit consumption, self-efficacy, attitudes, preferences, knowledge, and intentions mediated the association of parental education with children's vegetable and fruit consumption(30, 31). These factors may explain the association of parental education with children's vegetable and fruit consumption.

We furthermore observed associations of material deprivation with low vegetable and fruit consumption. This is in agreement with a Canadian study in which 3,099 1- to 5-year-olds from parents reporting difficulty buying food had higher odds of consuming less vegetables and fruits(32). Furthermore, in several American studies it has been observed that costs of vegetables and fruits limited their availability at home and were a barrier for adequate vegetable and fruit consumption(33, 34). Adding to this, in the

Netherlands, higher dietary costs were associated with healthier foods(35). Moreover, the prices of healthy foods increased more than prices of unhealthy foods in the past years(35). Interestingly, we found no association of perceived financial difficulties with low vegetable or fruit consumption. It could be that some parents who reported material deprivation perceived no financial difficulties or vice versa(36). Indeed, 18.2% reported financial difficulties and no material deprivation and 11.2% reported material deprivation and no financial difficulties.

In our study we observed an association of living in a neighbourhood with a low NSES with a low vegetable consumption but not a low fruit consumption in children. This partially support findings from earlier studies such as the Young Finns Cohort study in which the prevalence of a low vegetable and fruit consumption was higher in children from neighbourhoods with a low NSES(37). Earlier studies have reported that there are more convenience stores and fast food outlets in low NSES neighbourhoods(38-40). It is hypothesized that this possibly results in a higher consumption of ready-to-eat foods and a lower consumption of vegetables and fruits(38-40). An effect study on free provision of vegetables and fruits at Dutch primary schools showed a long-term significant increase in fruit consumption but not in vegetable consumption(41).The authors suggest that their finding may be due to Dutch eating habits, namely consuming vegetables at home during dinner whereas fruits are mainly consumed during the day at school(41). One could postulate that, because of school policies, NSES has less influence on fruit consumption. At the time of data collection, there were school prevention programs with fruit components implemented in Rotterdam, but data on the reach of these programs is missing. The impact on our results is therefore unclear.

We also observed that a non-Western migrant status was associated with a low vegetable consumption but not with a low fruit consumption. As previously mentioned, fruit consumption is possibly more influenced by school policies than vegetable consumption(41). According to a systematic mapping review, differences in beliefs and perceptions of healthy foods, acculturation, and socialization may play a role in dietary behaviours in ethnic minorities living in Europe(42). Our results differ from earlier research in which non-Western children consumed more vegetables and fruits than Western children(42). However, these children in earlier research mostly were adolescents or data were analyzed together with adults. Also, these studies took place in other European countries than our study (i.e. Norway, Denmark, Switzerland, Croatia and most from the United Kingdom). Some of these countries such as the United Kingdom have a different composition and origin of migrants and migration than the Netherlands(43). To illustrate, in the Netherlands most non-Western migrants have a Turkish, Moroccan or Surinamese background and in the United Kingdom most non-Western migrants have an

Indian, Pakistani, Chinese or Bangladeshi background(43, 44). Also, these studies were performed between 2000-2011(42). The children with a migrant status in our sample were mostly born in the Netherlands and were thus second generation migrant children (82.6%). It is hypothesized that these children and their parents could have experienced more acculturation towards a Western diet. This is in concordance with a systematic review that studied acculturation in relation to weight gain in high-income countries. In this review an overall positive association of a higher degree of acculturation of migrants with obesity was found(45). We categorized children from non-Western countries in one group and children from Western countries in another group. Non-Western countries or Western countries may differ from each other in economy, religion, culture, diet, and lifestyle. Therefore, these groups could be heterogeneous regarding diet and lifestyle.

In our study we sought to identify potential target groups at which interventions could be directed. Figure 3 shows the associations that we found of the SES indicators and migrant status with risk of low vegetable consumption and low fruit consumption in children in our data. We did this by studying associations of multiple SES indicators and migrant status with a low vegetable and fruit consumption jointly. We want to emphasize that our estimates therefore cannot be interpreted as causal effects(46). Likewise, distinguishing direct and indirect effects of our effect estimates is not possible(46). We have not performed causal mediation analysis in our cross-sectional data as this was not the goal of our study. Moreover, using cross-sectional data, no causation or temporal direction can be established. Therefore, we cannot report on possible mediators underlying associations of SES indicators and migrant status with vegetable and fruit consumption. To gain more insight into these associations longitudinal mediation studies are warranted. As we did not perform spatial analyses we do not know whether

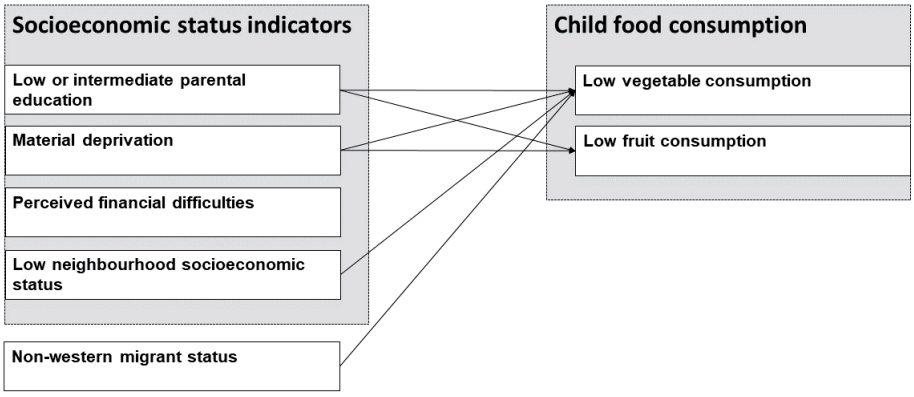


**Figure 3.** Observed associations of socioeconomic status indicators and migrant status with low vegetable and low fruit consumption in children.

neighbourhood effects spatially cluster or not. We recommend future research to examine both multilevel and spatial regression jointly to examine both neighbourhood variation as well as the pattern of variation between neighbourhoods(47).

Strengths of this study include the large and diverse population-based sample which are both important for the generalizability of our findings. Another strength is that we could include multiple indicators of socioeconomic status on the family/individual as well as the neighbourhood level into our analysis. There are also some limitations. As previously mentioned, the cross-sectional design of the study makes it impossible to establish causation or a temporal direction. NSES had 15.5% missing values, which could potentially impact the results. However, our complete-case analysis yielded similar results as our multiple-imputed analysis. We used dichotomized measure of NSES as more categories resulted in empty cells in the multilevel analysis. Also, individual measures used for creating the NSES variable were not available and could not be included in our analysis. We only measured the number of days that children consumed vegetables/fruits. Furthermore, the perception of vegetables/fruits is variable and socially desirable answers could have biased the results(48). We dichotomized migrant status because of limited participants in some substrata which may have masked subgroup effects. Lastly, residual confounding by unmeasured or imprecisely measured confounders could also be present.

## Conclusion

In conclusion, multiple SES indicators and migrant status are associated with a higher risk of a low vegetable and fruit consumption in 4- to 12-year-olds. Our results are important for researchers, policymakers, and health professionals as they help to identify potential target groups for interventions.

## SUPPLEMENTAL MATERIAL

**Table S1.** Testing interaction effects in the fully adjusted models.

| | Low vegetable consumption | Low fruit consumption |
|---|---|---|
| **Parental education with** | | |
| Gender | 0.11 | 0.46 |
| Family situation | 0.59 | 0.59 |
| Age | 0.68 | 0.25 |
| Material deprivation | 0.04 | 0.32 |
| Perceived financial difficulties | 0.61 | 0.27 |
| NSES | 0.01 | 0.18 |
| Migrant status | 0.01 | 0.27 |
| **Material deprivation with** | | |
| Gender | 0.40 | 0.79 |
| Family situation | 0.56 | 0.92 |
| Age | 0.16 | 0.34 |
| Perceived financial difficulties | 0.19 | 0.12 |
| NSES | 0.27 | 0.25 |
| Migrant status | 0.75 | 0.58 |
| **Perceived financial difficulties with** | | |
| Gender | 0.75 | 0.35 |
| Family situation | 0.10 | 0.06 |
| Age | 0.10 | 0.71 |
| NSES | 0.97 | 0.46 |
| Migrant status | 0.27 | 0.28 |
| **NSES with** | | |
| Gender | 0.01 | 0.37 |
| Family situation | 0.70 | 0.43 |
| Age | 0.72 | 0.28 |
| Migrant status | 0.53 | 0.22 |
| **Migrant status with** | | |
| Gender | 0.42 | 0.14 |
| Family situation | 0.68 | 0.10 |
| Age | 0.20 | 0.18 |

Interaction effects of sociodemographic variables (i.e. age, gender and family situation), SES indicators and migrant status were assessed by adding interaction terms one by one in the fully adjusted models (model 3). A Bonferroni correction was used to investigate significant interaction effects (p=0.05/25=0.002) NSES=Neighborhood SES).

**Table S2.** Associations of socioeconomic indicators and migrant status with non-daily vegetable consumption (N=5,010).

| | Null model OR (95% CI) | Model 1 OR (95% CI) | Model 2 OR (95% CI) | Model 3 OR (95% CI) |
|---|---|---|---|---|
| | | Separate models | | Combined model |
| **Parental education** | | | | |
| Low | | **1.88 (1.59, 2.23)** | **1.88 (1.59, 2.24)** | **1.76 (1.47, 2.11)** |
| Intermediate | | **1.56 (1.36, 1.78)** | **1.56 (1.37, 1.79)** | **1.48 (1.29, 1.70)** |
| Higher | | Ref | Ref | Ref |
| **Material deprivation** | | | | |
| Yes | | **1.48 (1.28, 1.70)** | **1.47 (1.28, 1.70)** | **1.39 (1.16, 1.66)** |
| No | | Ref | Ref | Ref |
| **Perceived financial difficulties** | | | | |
| Yes | | **1.24 (1.06, 1.45)** | **1.23 (1.04, 1.44)** | 0.92 (0.75, 1.12) |
| No | | Ref | Ref | Ref |
| **NSES** | | | | |
| Low | | **1.24 (1.03, 1.49)** | **1.23 (1.02, 1.48)** | 1.07 (0.89, 1.28) |
| High | | Ref | Ref | Ref |
| **Migrant status** | | | | |
| Non-Western | | **1.24 (1.10, 1.40)** | **1.23 (1.09, 1.39)** | 1.06 (0.93, 1.21) |
| Western | | Ref | Ref | Ref |
| **MOR** | 1.44 | | | 1.37 |

OR=Odds Ratio; CI=Confidence interval; NSES=Neighbourhood Socioeconomic Status; MOR=Median Odds Ratio (exp(sqrt(2*variance random intercept)*0.6745; Numbers in **bold** indicate significance (P <0.05) Null model=intercept only; model 1 is a crude, unadjusted model; model 2 is adjusted for the age, gender (boy=ref) and family situation of the child (two-parent family=ref); model 3 is model 2 and additionally adjusted for all indicators of socioeconomic status and migrant status.

**Table S3.** Associations of socioeconomic indicators and migrant status with non-daily fruit consumption (N=5,010).

| | Null model OR (95% CI) | Model 1 OR (95% CI) | Model 2 OR (95% CI) | Model 3 OR (95% CI) |
|---|---|---|---|---|
| | | Separate models | | Combined model |
| **Parental education** | | | | |
| Low | | **1.28 (1.09, 1.52)** | 1.18 (1.00, 1.40) | 1.17 (0.98, 1.40) |
| Intermediate | | **1.23 (1.07, 1.40)** | **1.19 (1.03, 1.36)** | **1.17 (1.02, 1.35)** |
| Higher | | Ref | Ref | Ref |
| **Material deprivation** | | | | |
| Yes | | **1.51 (1.31, 1.74)** | **1.49 (1.29, 1.72)** | **1.56 (1.30, 1.87)** |
| No | | Ref | Ref | Ref |
| **Perceived financial difficulties** | | | | |
| Yes | | **1.27 (1.08, 1.49)** | **1.23 (1.05, 1.46)** | 0.92 (0.75, 1.13) |
| No | | Ref | Ref | Ref |
| **NSES** | | | | |
| Low | | 0.92 (0.78, 1.10) | 0.90 (0.76, 1.07) | 0.86 (0.72, 1.03) |
| High | | Ref | Ref | Ref |
| **Migrant status** | | | | |
| Non-Western | | 0.98 (0.86, 1.11) | 0.94 (0.83, 1.07) | 0.87 (0.76, 1.00) |
| Western | | Ref | Ref | Ref |
| **MOR** | 1.32 | | | 1.28 |

OR=Odds Ratio; CI=Confidence interval; NSES=Neighbourhood Socioeconomic Status; MOR=Median Odds Ratio (exp(sqrt(2*variance random intercept)*0.6745)); Numbers in **bold** indicate significance (P <0.05) Null model=intercept only; model 1 is a crude, unadjusted model; model 2 is adjusted for age, gender (boy=ref) and family situation of the child (two-parent family=ref); model 3 is model 2 and additionally adjusted for all indicators of socioeconomic status and migrant status.

**Table S4.** Complete-case associations of socioeconomic status indicators and migrant status with low vegetable consumption (N=3,946).

| | Null model | Model 1 OR (95% CI) | Model 2 OR (95% CI) | Model 3 OR (95% CI) |
|---|---|---|---|---|
| | | Separate models | | Combined model |
| **Parental education** | | | | |
| Low | | **3,97 (3.21, 4.91)** | **4.00 (3.22, 4.97)** | **3.01 (2.41, 3.77)** |
| Intermediate | | **2.51 (2.08, 3.03)** | **2.52 (2.08, 3.05)** | **2.07 (1.70, 2.51)** |
| Higher | | Ref | Ref | Ref |
| **Material deprivation** | | | | |
| Yes | | **2.16 (1.82, 2.56)** | **2.15 (1.81, 2.56)** | **1.58 (1.27, 1.97)** |
| No | | Ref | Ref | Ref |
| **Perceived financial difficulties** | | | | |
| Yes | | **1.85 (1.52, 2.24)** | **1.82 (1.49, 2.21)** | 1.13 (0.89, 1.45) |
| No | | Ref | Ref | Ref |
| **NSES** | | | | |
| Low | | **2.19 (1.64, 2.92)** | **2.15 (1.62, 2.87)** | **1.32 (1.01, 1.71)** |
| High | | Ref | Ref | Ref |
| **Migrant status** | | | | |
| Non-Western | | **2.58 (2.19, 3.05)** | **2.57 (2,17, 3.04)** | **2.01 (1.69, 2.39)** |
| Western | | Ref | Ref | Ref |
| **MOR** | 1.71 | | | 1.36 |

Low vegetable consumption indicates a consumption on ≤4 days a week. OR=Odds Ratio; CI=Confidence interval; NSES=Neighbourhood Socioeconomic Status; MOR=Median Odds Ratio (exp(sqrt(2*variance random intercept)*0.6745)); Numbers in **bold** indicate significance (P <0.05) Null model=intercept only; model 1 is a crude, unadjusted model; model 2 is adjusted for age, gender (boy=ref) and family situation of the child (two-parent family=ref); model 3 is model 2 and additionally adjusted for all indicators of socioeconomic status and migrant status.

**Table S5.** Complete-case associations of socioeconomic status indicators and migrant status with low fruit consumption (N=3,946).

| | Null model OR (95% CI) | Model 1 OR (95% CI) | Model 2 OR (95% CI) | Model 3 OR (95% CI) |
|---|---|---|---|---|
| | | Separate models | | Combined model |
| **Parental education** | | | | |
| Low | | **2.21 (1.70, 2.88)** | **1.98 (1.51, 2.58)** | **1.82 (1.37, 2.40)** |
| Intermediate | | **1.56 (1.23, 1.97)** | **1.50 (1.18, 1.90)** | **1.40 (1.10, 1.79)** |
| Higher | | Ref | Ref | Ref |
| **Material deprivation** | | | | |
| Yes | | **1.74 (1.40, 2.15)** | **1.64 (1.32, 2.05)** | **1.67 (1.27, 2.19)** |
| No | | Ref | Ref | Ref |
| **Perceived financial difficulties** | | | | |
| Yes | | **1.31 (1.02, 1.69**) | 1.21 (0.93, 1.56) | 0.81 (0.59, 1.10) |
| No | | Ref | Ref | Ref |
| **NSES** | | | | |
| Low | | 1.33 (0.93, 1.90) | 1.27 (0.89, 1.81) | 1.05 (0.74, 1.49) |
| High | | Ref | Ref | Ref |
| **Migrant status** | | | | |
| Non-Western | | **1.27 (1.03, 1.57)** | 1.21 (0.98, 1.49) | 1.03 (0.83, 1.28) |
| Western | | Ref | Ref | Ref |
| **MOR** | 1.60 | | | 1.56 |

Low fruit consumption indicates a consumption on ≤4 days a week. OR=Odds Ratio; CI=Confidence interval; NSES=Neighbourhood Socioeconomic Status; MOR=Median Odds Ratio (exp(sqrt(2*variance random intercept)*0.6745)); Numbers in **bold** indicate significance (P <0.05) Null model=intercept only; model 1 is a crude, unadjusted model; model 2 is adjusted for age, gender (boy=ref) and family situation of the child (two-parent family=ref); model 3 is model 2 and additionally adjusted for all indicators of socioeconomic status and migrant status.

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# 3

# Independent contributions of family and neighbourhood indicators of socioeconomic status and migrant status to risk of mental health problems in 4-12 year old children

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## ABSTRACT

**Rationale:** A range of family and neighbourhood indicators of socioeconomic status and migrant status have been shown to be associated with risk of mental health problems (MHP) in children. In this study we determined the independent contributions of these indicators.

**Objectives*:*** The main objective is to examine independent associations of family and neighbourhood socioeconomic status indicators and migrant status with risk of MHP in children.

**Methods:** We analyzed data from an anonymous public health survey among 5,010 parents/caretakers of children aged 4-12 years living in Rotterdam, The Netherlands, gathered in 2018. Outcome of interest was risk of MHP measured using the total difficulties score of the Strengths and Difficulties Questionnaire. Associations of parent-reported perceived financial difficulties, material deprivation (not being able to provide certain goods, or leisure, educational or cultural activities or care use for children due to financial restrictions), parental educational level, child's migrant status and neighbourhood socioeconomic status with risk of MHP and with the total difficulties score were assessed using multilevel multivariable logistic and linear regression models.

**Results:** In total, 473 (9.5%) children had a high risk of MHP. We observed independent associations of perceived financial difficulties, material deprivation and parental educational level with risk of MHP and with an increase in total difficulties score ($P < 0.05$). Migrant status and neighbourhood socioeconomic status were not independently associated with risk of MHP or a change in total difficulties score.

**Conclusions:** Already in early life perceived financial difficulties by parents, material deprivation reported by parents and lower parental education appeared to be independently associated with the risk of MHP in 4-12 year olds. Health professionals should be aware of the relatively higher risks in these subgroups and consider policies addressing this.

## INTRODUCTION

Approximately 10-20% of children and adolescents worldwide experience mental health problems (MHP)(1). Onset of MHP usually occurs during childhood or adolescence with key MHP such as anxiety, depression, self-harm, ADHD (attention-deficit hyperactivity disorder), conduct disorders, PTSD (post-traumatic stress disorder) and eating disorders(2-5). MHP in childhood may have a long lasting effect and track into adulthood(1, 6). Poor mental health is associated with multiple negative consequences such as employment difficulties, educational attainment and substance use later in life(1, 6). Timely awareness and intervention in childhood may reduce the severity and persistence of MHP(3).

According to Cheng and Goodman (2015) and Braveman (2005) socioeconomic status is a multidimensional construct which consists of several different but highly related indicators such as income, education, employment and neighbourhood characteristics(7, 8). Migrant status is also highly related but not similar to socioeconomic status(7). Braveman (2005) put forward that different socioeconomic status indicators affect health through distinct, possibly interacting, pathways at different levels (e.g. individual, family or neighbourhood) and therefore recommends studying different socioeconomic indicators(8). Children from disadvantaged backgrounds or with a migrant status were found to have an increased risk of MHP(9-12).

Limited research has been performed to elucidate independent associations of socioeconomic indicators with MHP while this may increase our understanding of the differential, possibly interacting, pathways underlying these associations. These insights may give implications for policy making and practice.

Several cohort studies observed associations of perceived financial difficulties, poverty or material deprivation (not being able to provide certain goods, or leisure, educational or cultural activities or care use for children due to financial restrictions) with MHP in children(13-15). For example a study performed in (N=6,330) children aged 4-16 from several Nordic countries demonstrated an association of perceived financial difficulties with MHP in children(15). A possible underlying mechanism is that perceived financial difficulties and material deprivation limit the goods and activities (for example leisure, educational or cultural activities or care use) that contribute to children's development, makes children different from their more affluent peers and in turn may influence mental health of children(16). A second mechanism, the so-called family-stress model, suggests that perceived financial difficulties and material deprivation lead to parental stress affecting parental mental health and in turn their children's mental health(16).

Indeed, in the generation R cohort it was found that maternal depressive symptoms mediated the association of perceived financial difficulties and material deprivation with mental health problems in their three-year-old children (N=2,169). Moreover, some parents with an income above the poverty line may still experience financial difficulties or material deprivation while other parents with a low income may not perceive financial difficulties(17). Therefore, perceived financial difficulties or material deprivation may be important indicators of socioeconomic status in the association with MHP in children.

Other studies have examined associations of parental educational level or migrant status with MHP in children(18-21). Lower parental educational level or a non-Western migrant status were both associated with MHP in children (N=3,100) aged 4-14 years old in a Spanish cross-sectional study(20). In a Dutch longitudinal study in children (N=3,410) aged 5-6 years old, lower-educated mothers reported more MHP in their children(19). Parental educational level may be associated with differences in lifestyle, parenting choices, skills, and differences in providing adequate resources or help and in turn influence the MHP of their children(18). Cultural differences due to migration, discrimination, differences in social position, asymmetrical acculturation within families and differences in parenting styles may directly or indirectly lead to a higher risk of MHP in migrant children(21).

Some studies have examined associations of neighbourhood indicators of socioeconomic status with MHP in children(11). In a Swedish cohort study, an association of the socioeconomic status of the neighbourhood with a higher risk of MHP in children and adolescents was found(10). Whereas, in a British cohort study, in 10-15 year old children an association with risk of MHP was observed, but most variability was explained by family indicators of socioeconomic status(22). Previous literature has suggested that neighbourhoods with much poverty and/or unemployment may influence child MHP(16, 23).

Earlier research has shown associations of a range of family and neighbourhood indicators of socioeconomic status and migrant status with risk of MHP in children. Yet it is unclear what their independent contribution is. In particular, insight in independent contributions of perceived financial difficulties and material deprivation and their influence on children's risk of MHP is limited.

Therefore, the goal of this study was to examine independent associations of family (perceived financial difficulties, material deprivation, and parental educational level) and neighbourhood (neighbourhood socioeconomic status) indicators of socioeconomic status and of migrant status with risk of MHP in children. More insight in the

independent contributions of these variables may have implications for better targeted preventive policies and practice aiming to reduce socioeconomic inequalities in youth MHP. In our study we will focus on 4-12 year old children as MHP can already be present at a young age and early intervention could reduce severity and persistence(2-5).

### Research questions

1) Are family indicators of socioeconomic status (perceived financial difficulties, material deprivation, lower or intermediate parental educational level) independently associated with MHP in 4-12 year old children?
2) Is the socioeconomic status of the neighbourhood independently associated with MHP in 4-12 year old children?
3) Is a non-Western migrant status of the child independently associated with MHP in 4-12 year old children?
4) Is there an interaction effect of age, gender or family situation with indicators of socioeconomic status or with migrant status or between indicators or socioeconomic status and migrant status?

## METHODS

### Study population and design

Data were used from a cross-sectional Dutch public health survey carried out in 2018 by the municipal public health service in the city of Rotterdam (Gezondheidsmonitor Kinderen GGD Rotterdam-Rijnmond). The survey targeted parents/caretakers of children aged 0-12 years old and questionnaires were filled out by the main caregiver. For our study we used survey data of parents of children aged 4-12 years old as the Strengths and Difficulties questionnaire (SDQ) to measure risk of MHP was not assessed in younger children. Invitations to participate were done by drawing a random probability sample from the municipal population register stratified by neighbourhood. Children who were living in a healthcare institution were excluded and parents received an invitation for one child only. All parents were living in Rotterdam when the survey was administered. Parents received hardcopy invitation letters with information about the survey and login details for the online survey. A hardcopy questionnaire was sent with the second time parents received the invitation. Parents could refuse to participate by not filling out the questionnaire. The survey data were collected by online or hardcopy questionnaires offered in Dutch, English and Turkish. Non-responders were contacted by telephone and were offered extra help in completing the questionnaire. Extra effort was made to target parents with Turkish and Moroccan backgrounds and residents of neighbourhoods with a low response. Parents/caretakers of N=5,010 children aged 4-12 years old participated.

The response rate was 34% and varied between 23-54% depending on the neighbourhood. Response did not differ by age or gender of the children.

A comparison of parents of children with missing data (N=1,047; 20.9%) with parents of children with complete data (N=3,963; 79.1%) showed that parents of children with missing data less often reported material deprivation, were higher educated, more often from a Western migrant status or Dutch and more often lived in a neighbourhood with a lower socioeconomic status ($p < 0.05$). Parents of children with missing data did not differ according to perceived financial difficulties, family situation, gender, age, and total difficulties score ($p > 0.05$).

## Ethics

Our study relied on anonymous survey data collected in the context of performing statutory tasks (Public Health Act Netherlands). Observational research with anonymous data does not fall within the ambit of the Dutch Act on research involving human subjects and does not require the approval of an ethics review board. The Dutch Code of Conduct for Medical Research allows the use of anonymous data for research purposes without an explicit informed consent(24). Parents were free to refuse participation and could refuse by not filling out the questionnaire.

## Measures

### *Perceived financial difficulties*

Perceived financial difficulties was assessed by the question: Have you had difficulties in the past 12 months making ends meet with your household income? This question had four answer categories: no difficulty at all (60.6%), no difficulty but I do have to keep an eye on what I spend (24.1%), yes some difficulty (11.6%), and yes a lot of difficulty (3.7%). For the analyses the answers were dichotomized as either: no (no difficulty at all and no difficulty but I do have to keep an eye on what I spend) and yes (yes some difficulty and yes a lot of difficulty).

### *Material deprivation*

Eight statements assessed material deprivation (not being able to provide certain goods, or leisure, educational or cultural activities or care use for children due to financial restrictions):

1) my child cannot be a member of a sports club;
2) my child cannot be a member of another club such as theater or music;
3) my child cannot attend birthday parties or trips with school;
4) we cannot go on holiday or days-out;

5) my child cannot eat fruit or vegetables daily;
6) my child cannot attend swimming lessons;
7) my child cannot go to a care provider if that is actually necessary;
8) my child cannot receive the medication or care that is needed.

These statements are based on EU-SILC questions(25). The eight statements were transformed to a material deprivation score ranging from zero to eight, with eight being the highest score (i.e. parents could not afford any of the eight items). We did this by computing a score in which every statement answered with yes counted as a one and every statement answered with no as a zero. Internal consistency of the scale was good (Cronbach's alpha of 0.85). For the analyses the score was dichotomized to either no material deprivation or material deprivation (at least one of the eight items showed deprivation). We dichotomized the scale because the distribution of the scale was skewed (i.e. 0.5% of the parents could not afford any of the eight items (showed deprivation) to 77.9% of the parents who could afford all eight items).

***Migrant status***

Migrant status was dichotomized as non-Western migrant (41.1%) or Western migrant together with Dutch natives (45.8%). Western migrants consisted of 13.1% of the total sample. We refer to this category as Western migrant and Dutch. A child was considered to have a non-Western migrant status as either the child was not born in a Western country or one or both parents were not born in a Western country. The following countries were considered Western: Europe (except Turkey), North America, Oceania, Indonesia and Japan in accordance with Statistics Netherlands(26).

***Parental educational level***

Parental educational level was defined as highest educational level obtained by one of the parents. Thus we categorized education based on the parent who obtained the highest education. Parental educational level was categorized as lower (no education, primary school or ≤ 4 years general secondary school), intermediate (> 4 years general secondary school or intermediate vocational training) and higher education (higher vocational training, university degree or higher)(27).

***Neighbourhood socioeconomic status***

The most recent data about the socioeconomic status of the neighbourhood (2017) were obtained from the Netherlands Institute of Social Research (SCP)(28). Matching to the questionnaire data was done using the neighbourhood code. The SCP computed a socioeconomic status score of the neighbourhood using principal component analysis based on mean adult income, percentage low adult incomes, percentage of low educat-

ed adult residents and percentage of unemployed adult residents in a neighbourhood. Previously, these scores have been found to be associated with health outcomes(29, 30). We computed tertiles of the neighbourhood socioeconomic status scores to create equal sized groups. The lowest tertile corresponds with a lower socioeconomic status score, the second tertile corresponds with an intermediate socioeconomic status score and the highest tertile corresponds to a higher socioeconomic status score. In total, 57 neighbourhoods in Rotterdam were included in our study. The amount of parents and children per neighbourhood in our sample varied from 30-160 with a mean of 88 (median=84). Out of these 57 neighbourhoods we classified 18 as lower (32.7%; N=1,642), 18 as intermediate (30.7%; N=1,539), 13 as higher (21.1%; N=1,054) socioeconomic status and 8 were not classified (15.5%; N=775).

***Outcome assessment***

*Risk of MHP*

Risk of MHP in children was measured using the parent-strengths and difficulties questionnaire (SDQ) included in the Dutch Public health survey(31).The SDQ is a validated tool(32, 33). Internal consistency of the total difficulties score in our sample was adequate (Cronbach's alpha of 0.73). The SDQ consists of the following domains: emotional problems, conduct problems, hyperactivity, peer problems, and prosocial behavior. A total difficulties score of the SDQ was calculated by adding the sub-scores of all domains except for the prosocial domain. The total difficulties score was dichotomized as either a high total difficulties score (above the cut-off for risk of MHP) or a not-at-risk score (below the cut-off) based on Dutch validated age-dependent cut-off values(33). For children aged 4-7 years old a total difficulties score of ≥ 15 indicates risk of MHP and for children aged 7-12 years old of the cut-off is ≥ 14(33).

***Covariate assessment***

Age, gender and family situation of the child were considered possible confounders based on literature and were derived from the survey(9, 10, 13). Age was measured in years. Gender was measured as a dichotomous variable using boy as reference category. Family situation was measured as two-parent family, single-parent family, or other situation using two-parent family as the reference.



## Statistical analyses

Characteristics are presented as means ± standard deviations (SDs) for continuous variables and as percentages for categorical variables for the total study population and stratified by risk of MHP (a high total difficulties score) and a not-at risk score. Differences in characteristics between children with a not-at-risk score or risk of MHP (a high total

difficulties score) were computed using unpaired two-sample t-tests for continuous data and Chi-square tests for categorical data.

Missing data (ranging from 0.2% to 15.5%, see Table 1.) were imputed with SPSS using a fully conditional specified model based on the relationships between all the variables included in this study (M=10 datasets). Pooled estimates were used to obtain the odds ratio's (OR), betas and corresponding 95% confidence intervals (CI) using the imputed data.

To assess associations of perceived financial difficulties, material deprivation, parental educational level, migrant status and the socioeconomic status of the neighbourhood with risk of MHP (a high total difficulties score) in children we used multivariable multilevel logistic regression analyses. We used a random intercept and fixed slopes model to obtain the ORs and corresponding 95%CIs of having MHP (a high total difficulties score) as compared to a not-at-risk score. First we computed an intercept-only model to obtain the Median Odds Ratio (MOR). We also computed the MOR for the adjusted models. The MOR is used to examine the variance explained by the neighbourhood(34). The MOR shows the median value of the distribution of the odds ratio between the neighbourhood with the lowest risk and the neighbourhood with the highest risk(34, 35). The MOR varies between 1 and infinity. If the MOR is 1 there is no variation between neighbourhoods(35). We adjusted for confounding using three models. Model 1 is a crude model and not adjusted for confounders. Model 2 is adjusted for age and gender of the child and for family situation. Model 3 is additionally adjusted for all other family level socioeconomic status indicators (perceived financial difficulties, material deprivation, educational level), migrant status and for the socioeconomic status of the neighbourhood to obtain the independent associations.

Subsequently, multivariable multilevel linear regression analyses were performed using the total difficulties score as continuous outcome measure. First we computed an intercept-only model to obtain the intraclass correlation (ICC). We also computed the ICC for our adjusted models. The ICC is used to examine the variability between neighbourhoods and ranges between 0-1. The closer the ICC is to 1 the more variability there is between neighbourhoods. We regarded an ICC smaller than 0.01 as negligible. We adjusted for confounding similarly as for the logistic multivariable multilevel regression analysis. All correlations stayed well below 0.7 and all variance inflation factor (VIF) values below 2. Two sided p-values denoted statistical significance ($P < 0.05$). IBM SPSS statistics for Windows, version 25.0 (International Business Machines Corporation, Armonk, New York) was used for all analyses.

## RESULTS

Table 1 shows characteristics of the total sample and stratified by risk of MHP versus not-at-risk scores. A total of 473 (9.5%) children had risk of MHP (a high total difficulties score). Children with risk of MHP (a high total difficulties score) were more likely to be older, boy, to live in a single-parent or other family situation, had a non-Western migrant

**Table 1.** Characteristics of the study population stratified by risk of MHP or not-at-risk total difficulties score in in N =5,010 Children living in Rotterdam, the Netherlands in 2018.

| | | Total population | Not-at-risk score[1] | Risk of MHP[1] score[1] | P-value |
|---|---|---|---|---|---|
| %, N | | 5,010 | 90.5 (4,509) | 9.5 (473) | |
| Age | | 7.58 (2.29) | 7.52 (2.30) | 8.10 (2.09) | <**0.0001** |
| Gender | Boy | 51.6 (2,584) | 50.4 (2,271) | 62.8 (297) | **<0.0001** |
| | Girl | 48.4 (2,426) | 49.6 (2,238) | 37.2 (176) | |
| Family situation[2] | Two-parent | 74.7 (3,717) | 75.8 (3,395) | 66.0 (310) | **<0.0001** |
| | Single-parent or other | 25.3 (1,256) | 24.2 (1,081) | 34.0 (160) | |
| Perceived financial difficulties[3] | No | 84.7 (4,197) | 86.1 (3,846) | 71.3 (330) | **<0.0001** |
| | Yes | 15.3 (756) | 13.9 (620) | 28.7 (333) | |
| Material deprivation[4] | No | 77.9 (3,828) | 79.5 (3,525) | 61.9 (283) | **<0.0001** |
| | Yes | 22.1 (1,086) | 20.5 (910) | 38.1 (174) | |
| Migrant status[5] | Western migrant and Dutch | 58.9 (2,938) | 60.0 (2,691) | 49.4 (232) | **<0.0001** |
| | Non-Western migrant | 41.1 (2,046) | 40.0 (1,795) | 50.6 (238) | |
| Parental educational level[6] | Higher | 51.1 (2,459) | 52.9 (2,299) | 35.4 (155) | **<0.0001** |
| | Intermediate | 32.3 (1,554) | 31.4 (1,367) | 40.9 (179) | |
| | Lower | 16.6 (796) | 15.7 (682) | 23.7 (104) | |
| Neighbourhood socioeconomic status[7] | Higher | 24.9 (1,054) | 25.6 (971) | 19.7 (82) | **0.007** |
| | Intermediate | 36.3 (1,539) | 36.5 (1,385) | 35.5 (148) | |
| | Lower | 38.8 (1,642) | 38.0 (1,441) | 44.8 (187) | |

Data expressed as M ± SD for continuous data and p-value computed using Unpaired T-tests. Data expressed as % for categorical data and p-value computed using chi-square tests. A high total difficulties score corresponds with a score above the age dependent cut off: score (e.g. for children aged 4-7 years old ≥ 15 and for children aged 7-12 ≥ 14). [1] 28 (0.6%) are missing; [2] 37 are missing (0.7%); [3] 57 are missing (1.1%); [4] 96 are missing (1.9%); [5] 26 are missing (0.5%); [6] 201 are missing (4.0%); [7] 775 are missing (15.5%).
MHP=mental health problems.

status and were from neighbourhoods with a lower socioeconomic status compared to children with a not-at-risk score ($p < 0.05$). These children were also more likely to have parents who perceived financial difficulties, had material deprivation or were intermediate educated ($p < 0.05$).

Table 2 presents results of the multilevel multivariable logistic regression analyses. The intercept-only model shows a MOR of 1.36 indicating some variation/heterogeneity between neighbourhoods in risk of MHP (high versus not-at-risk). Model 3 shows that parental perceived financial difficulties (OR 1.56; 95% CI: 1.18, 2.07), material deprivation (OR 1.53; 95% CI: 1.17, 1.99) and a lower (OR 1.74; 95% CI: 1.33, 2.28) and intermediate parental educational level (OR 1.69; 95% CI: 1.34, 2.13) were all significantly independently associated with risk of MHP (a high total difficulties score) compared to a not-at-risk score in children. Migrant status and the socioeconomic status of the neighbourhood were not significantly associated with risk of MHP (a high total difficulties score) in children after full adjustment in model 3.

Table 3 shows the results of the multilevel multivariable linear regression analyses. The ICC of the intercept-only model is 1.6% which is relatively low. Model 3 shows that all family level indicators of socioeconomic status were independently associated with the total difficulties score, namely: perceived financial difficulties (beta 1.50; 95% CI: 1.04, 1.97) material deprivation (beta 1.37; 95% CI: 0.94, 1.79) and a lower (beta 0.98; 95% CI: 0.45, 1.51) and intermediate educational level (beta 0.68; 95% CI: 0.27, 1.08). Migrant status and neighbourhood socioeconomic status were not associated with a higher total difficulties score after full adjustment in model 3 ($P > 0.5$).

Sensitivity analyses using a complete case sample of N=3,963 participants yielded similar results for the risk of a high total difficulties score and for change in total difficulties score (See Table SA and SB). However, besides perceived financial difficulties, material deprivation, and parental education, also a lower socioeconomic status of the neighbourhood is significantly associated with a change in the total difficulties score (beta 0.52; 95% CI: 0.04, 0.99). Interaction effects were explored between all socioeconomic status indicators and migrant status. Interaction effects were also explored between age and gender of the child, family situation and socioeconomic status indicators and migrant status. After applying the Bonferroni correction for multiple testing ($p= 0.05/25 =0.002$), no significant interaction was found.

**Table 2.** Multilevel associations of family and neighbourhood indicators of socioeconomic status and migrant status with risk of MHP in N=5,010 children living in Rotterdam, the Netherlands in 2018.

| | Null model | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|---|
| **Level 1: family** | | | | |
| **Perceived financial difficulties** | | | | |
| Yes | | **2.39 (1.92, 2.96)** | **2.26 (1.80, 2.83)** | **1.56 (1.18, 2.07)** |
| No | | Ref | Ref | Ref |
| **Material deprivation** | | | | |
| Yes | | **2.31 (1.89, 2.81)** | **2.18 (1.78, 2.69)** | **1.53 (1.17, 1.99)** |
| No | | Ref | Ref | Ref |
| **Migrant status** | | | | |
| Non-Western migrant | | **1.50 (1.23, 1.82)** | **1.42 (1.17, 1.73)** | 1.12 (0.91, 1.39) |
| Western migrant and Dutch | | Ref | Ref | Ref |
| **Parental education** | | | | |
| Lower | | **2.29 (1.79, 2.94)** | **1.99 (1.55, 2.56)** | **1.74 (1.33, 2.28)** |
| Intermediate | | **2.00 (1.61, 2.49)** | **1.88 (1.50, 2.34)** | **1.69 (1.34, 2.13)** |
| Higher | | Ref | Ref | Ref |
| **Level 2: neighbourhood** | | | | |
| **Neighbourhood socioeconomic status** | | | | |
| Lower | | 1.28 (0.90, 1.82) | 1.22 (0.88, 1.70) | 1.02 (0.75, 1.39) |
| Intermediate | | 1.15 (0.81, 1.15) | 1.10 (0.79, 1.53) | 1.03 (0.75, 1.40) |
| Higher | | Ref | Ref | Ref |
| Neighborhood variance | 0.10 | | | 0.05 |
| **MOR** | 1.36 | | | 1.25 |

[1] Model 1 is the crude, unadjusted model.
[2] Model 2 is adjusted for age, gender (ref=boy), and family situation (ref=two-parent family).
[3] Model 3 includes model 2 and additionally adjusted for perceived financial difficulties (ref=no), material deprivation (ref=no), parental educational level (ref=higher), migrant status (ref=Western migrant and Dutch) and for neighbourhood socioeconomic status (ref=higher).
OR=odds ratio and represent odds of MHP (a high total difficulties score) compared to a not-at-risk score (ref= not-at-risk score).
CI=confidence interval.
Numbers in **bold** are significant.
MOR=median odds ratio, sum; exp(sqrt(2*neighbourhood variance)*0.6745)).

**Table 3.** Multilevel associations family and neighbourhood indicators of socioeconomic status and migrant status with the total difficulties score in N=5,010 children living in Rotterdam, the Netherlands in 2018.

| | Null model | Model 1<br>Change in total difficulties score (95% CI) | Model 2<br>Change in total difficulties score (95% CI) | Model 3<br>Chance in total difficulties score (95% CI) |
|---|---|---|---|---|
| **Level 1: family** | | | | |
| **Perceived financial difficulties** | | | | |
| Yes | | **2.71 (2.33, 3.08)** | **2.54 (2.16, 2.92)** | **1.50 (1.04, 1.97)** |
| No | | Ref | Ref | Ref |
| **Material deprivation** | | | | |
| Yes | | **2.46 (2.13, 2.78)** | **2.30 (1.96, 2.64)** | **1.37 (0.94, 1.79)** |
| No | | Ref | Ref | Ref |
| **Migrant status** | | | | |
| Non-Western migrant | | **0.63 (0.33, 0.92)** | **0.54 (0.24, 0.83)** | -0.00 (-0.33, 0.33) |
| Western migrant and Dutch | | Ref | Ref | Ref |
| **Parental education** | | | | |
| Lower | | **1.62 (1.15, 2.10)** | **1.37 (0.88, 1.87)** | **0.98 (0.45 1.51)** |
| Intermediate | | **1.14 (0.77, 1.52)** | **1.01 (0.63, 1.38)** | **0.68 (0.27, 1.08)** |
| Higher | | Ref | Ref | Ref |
| **Level 2: neighbourhood** | | | | |
| **Neighbourhood socioeconomic status** | | | | |
| Lower | | 0.73 (-2.46, 3.20) | 0.30 (-2.48, 3.08) | 0.15 (-1.55, 1.85) |
| Intermediate | | 0.20 (-1.22, 1.62) | 0.18 (-1.03, 1.39) | 0.03 (-1.02, 1.08) |
| Higher | | Ref | Ref | Ref |
| Random effect variance | 0.39 | | | 0.07 |
| Residual effect variance | 23.86 | | | 22.75 |
| **ICC (ICC%)** | 0.016 (1.6%) | | | 0.003 (0.3%) |

Change in total difficulties score is the difference (beta) in total difficulties score on the SDQ.

[1] Model 1 is the crude, unadjusted model.

[2] Model 2 is adjusted for age, gender (boy=ref), and family situation (ref=two-parent family).

[3] Model 3 includes model 2 and additionally adjusted for perceived financial difficulties (ref=no), material deprivation (ref=no), parental educational level (ref=higher), for migrant status (ref=Western migrant and Dutch) and for neighbourhood socioeconomic status (ref=higher).

CI=confidence interval.

Numbers in **bold** are significant.

ICC=intraclass correlation, sum; random effect variance / (random effect variance + residual effect variance). Here the percentage is given which is the ICC*100%.

## DISCUSSION

In this large population based cross-sectional study in 4-12 year old children, we found that children with parents who perceived financial difficulties, reported material deprivation or who obtained lower or intermediate education had a higher risk of MHP.

The prevalence of children with risk of MHP (a high total difficulties score) in our sample is in agreement with the prevalence of around 10-20% of children of this age experiencing MHP worldwide(36).

Perceived financial difficulties and material deprivation are both independently associated with risk of MHP in children in our study. Our findings are supported by other studies performed in the United Kingdom United States of America and Sweden(37-39). A possible explanation may be that not only poverty or quantitative income but also the experience of financial difficulties and material deprivation play a role(40). Although perceiving financial difficulties or experiencing material deprivation may be more common among parents living below the poverty line, some of these parents may be able to make the ends meet, for example because they have lower expenses or because they get support from others or by community organizations(17). Thus those parents may not perceive financial difficulties or material deprivation. Furthermore, some families living above the poverty line have for example higher expenses and less support and therefore may perceive financial difficulties or experience material deprivation. Perceiving financial difficulties or experiencing material deprivation may lead to stress and impact parental mental health and in turn increase the risk of MHP in their child(16). Indeed, in our sample 18.0% of the parents who perceive financial difficulties do not experience material deprivation and 11.7% of the parents who experience material deprivation do not perceive financial difficulties.

We also found an association of lower and intermediate parental education with risk of MHP in children. Associations of parental educational level with risk of MHP were also found in earlier research(19, 41, 42). Parental educational level was found to influence parental mental health through stress(43). Lower parental educational level was also found to influence parenting skills and choices such as lax, hostile or over reactive parenting(19, 41, 44, 45). Parental mental health, parental stress and parenting practices may influence the mental health of children(19). Yet, the exact pathway is still unclear.

We found no independent association of migrant status with risk of MHP. Earlier research found mixed results regarding migrant status(21). One possible explanation for these mixed results is that the effect of migration varies between certain migrant groups(21).

If so, studying different migrant groups as one group may lead to masked results. Another possible explanation is that differences in MHP in children with different migration backgrounds are due to socioeconomic circumstances(21). Indeed, after we adjusted our model for family socioeconomic indicators the association of migrant status with risk of MHP was no longer significant. At last, there may be cultural differences in what is perceived as MHP(21).

We found no association of a lower or intermediate neighbourhood socioeconomic status with risk of MHP. Other studies found associations of the socioeconomic status of the neighbourhood with a higher risk of MHP(10, 46, 47). In these studies, the age of the study population was on average older. It might be that for younger children familial circumstances and not neighbourhood circumstances are more important for mental health than for adolescents or adults. Another possible explanation is that younger children have less exposure to the neighbourhood, whereas older children or adolescents are able to experience the neighbourhood more and are more exposed to neighbourhood deprivation affecting their mental health(48).

Strengths of our study include the large sample size, a validated questionnaire to assess risk of MHP, the population-based setting and most importantly, a range of different socioeconomic status indicators. A key limitation is that due to the cross-sectional design of this study, no causation or temporal direction of the associations can be established. The survey data were not nationally representative and therefore the generalizability of our findings may be reduced. Moreover, our survey had a response rate of 34% which could lead to selection bias in our sample. Interestingly, Davern (2010) suggests that higher response rates do not automatically result in different estimates(49). We did not measure other family or neighbourhood indicators of socioeconomic status such as income or work situation. Using other indicators of socioeconomic status or different categorizations of indicators may lead to somewhat different results. The measure of the socioeconomic status of the neighbourhood has been used in previous research and was found to be associated with perinatal morbidity and health care costs(29, 30). However, no information regarding the validity or reliability of this measure is present. We based our study on survey data about topics that may be seen as sensitive such as MHP, perceived financial difficulties and material deprivation thus we need to be cautious of social desirability bias influencing the estimates. Finally, even though we adjusted for confounders, residual confounding might be present because of possible incompletely or unmeasured confounders.

This study contributes to the evidence that different indicators of socioeconomic status are independently associated with risk of MHP in children. Children growing up with

parents who perceive financial difficulties, report material deprivation and have lower educational levels have a higher risk of MHP. We recommend more research, preferably using longitudinal designs, to replicate our findings. For the development and implementation of effective preventive interventions and policies it is important to unravel possible distinct pathways for socioeconomic inequalities for MHP in children. Future studies applying mediation analyses could provide further insight in these pathways.

We observed distinct independent associations of family indicators of socioeconomic status with risk of MHP in children as young as 4-12 years old. Health professionals should be aware of the relatively higher risks in children with parents who perceive financial difficulties, material deprivation or who are lower or intermediate educated. Preventive interventions and policies should adequately address the specific needs of these particular subgroups and realize sufficient reach among them using insights on prevention of MHP in children(50). Preventive policies to reduce material deprivation of families, for example by in-kind-support policies, might be a promising way to improve mental health in children(17).

## Conclusion

We observed independent associations of perceived financial difficulties, material deprivation and parental educational level with an increased risk of MHP in children. Further research is warranted to confirm our findings and to unravel possible pathways underlying these associations with risk of MHP in children. To prevent MHP in children, policies and measures that target parents with lower or intermediate education or aimed to reduce parental perceived financial difficulties and material deprivation may be of importance.

## SUPPLEMENTAL MATERIAL

**Table SA.** Multilevel associations of socioeconomic indicators and migrant status with risk of MHP in N=3,963 4-12 year olds.

| | Null model | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|---|
| **Level 1: family** | | | | |
| **Perceived financial difficulties** | | | | |
| Yes | | **2.39 (1.87, 3.06)** | **2.31 (1.79, 2.98)** | **1.51 (1.10, 2.08)** |
| No | | ref | ref | ref |
| **Material deprivation** | | | | |
| Yes | | **2.44 (1.95, 3.06)** | **2.36 (1.87, 2.98)** | **1.69 (1.26, 2.27)** |
| No | | ref | ref | ref |
| **Migrant status** | | | | |
| Non-Western migrant | | **1.46 (1.17, 1.83)** | **1.40 (1.12, 1.75)** | 1.08 (0.85, 1.38) |
| Western migrant and Dutch | | ref | ref | Ref |
| **Parental education** | | | | |
| Lower | | **2.11 (1.58, 2.83)** | **1.90 (1.41, 2.57)** | **1.52 (1.11, 2.08)** |
| Intermediate | | **1.92 (1.50, 2.47)** | **1.85 (1.43, 2.39)** | **1.55 (1.18, 2.02)** |
| Higher | | ref | ref | ref |
| **Level 2: neighbourhood** | | | | |
| **Neighbourhood socioeconomic status** | | | | |
| Lower | | **1.72 (1.19, 1.48)** | **1.63 (1.13, 2.33)** | 1.23 (0.86, 1.76) |
| Intermediate | | 1.32 (0.91, 1.93) | 1.26 (0.87, 1.82) | 1.08 (0.76, 1.55) |
| Higher | | ref | ref | ref |
| Neighbourhood variance | 0.10 | | | 0.05 |
| **MOR** | 1.35 | | | 1.24 |

[1] Model 1 is the crude, unadjusted model.
[2] Model 2 is adjusted for age, gender (ref = boy), and family situation (ref = two-parent family).
[3] Model 3 includes model 2 and additionally adjusted for perceived financial difficulties (ref = no), material deprivation (ref = no), parental educational level (ref = higher), migrant status (ref = Western migrant and Dutch) and for neighbourhood socioeconomic status (ref = higher).
OR=odds ratio and represent odds of a high total difficulties (e.g. MHP) score compared to a not-at-risk score (ref= not-at-risk score).
CI=confidence interval.
Numbers in **bold** are significant.
MOR=median odds ratio, sum; exp(sqrt(2*neighbourhood variance)*0.6745)).

**Table SB.** Multilevel associations of socioeconomic indicators and migrant status with the total difficulties score on the SDQ in N=3,963 4-12 year olds.

| | Null model | Model 1<br>Change in total difficulties score (95% CI) | Model 2<br>Change in total difficulties score (95% CI) | Model 3<br>Chance in total difficulties score (95% CI) |
|---|---|---|---|---|
| **Level 1** | | | | |
| **Perceived financial difficulties** | | | | |
| Yes | | **2.59 (2.18, 3.01)** | **2.43 (2.01, 2.85)** | **1.35 (0.84, 1.86)** |
| No | | ref | ref | ref |
| **Material deprivation** | | | | |
| Yes | | **2.46 (2.11, 2.82)** | **2.31 (1.95, 2.68)** | **1.48 (1.03, 1.93)** |
| No | | ref | ref | ref |
| **Migrant status** | | | | |
| Non-Western migrant | | **0.54 (0.22, 0.87)** | **0.47 (0.15, 0.79)** | -0.09 (-0.41, 0.24) |
| Western migrant and Dutch | | ref | ref | Ref |
| **Parental education** | | | | |
| Lower | | **1.48 (1.04, 1.90)** | **1.24 (0.81, 1.68)** | **0.76 (0.31, 1.20)** |
| Intermediate | | **1.14 (0.79, 1.49)** | **1.00 (0.64, 1.35)** | **0.61 (0.26, 0.97)** |
| Higher | | Ref | ref | Ref |
| **Level 2** | | | | |
| **Neighbourhood socioeconomic status** | | | | |
| Lower | | **1.13 (0.60, 1.66)** | **0.99 (0.48, 1.51)** | **0.52 (0.04, 0.99)** |
| Intermediate | | 0.43 (-0.10, 0.97) | 0.35 (-0.17, 0.87) | 0.10 (-0.35, 0.56) |
| Higher | | ref | ref | ref |
| Random effect variance | 0.39 | | | 0.078 |
| Residual effect variance | 23.86 | | | 22.38 |
| **ICC (ICC%)** | 0.016 (1.6%) | | | 0.003 (0.3%) |

Change in total difficulties score is the difference (beta) in total difficulties score on the SDQ.
[1] Model 1 is the crude, unadjusted model.
[2] Model 2 is adjusted for age, gender (ref = boy), and family situation (ref = two-parent family).
[3] Model 3 includes model 2 and additionally adjusted for perceived financial difficulties (ref = no), material deprivation (ref = no), parental educational level (ref = higher), for migrant status (ref = Western migrant and Dutch) and for neighbourhood socioeconomic status (ref = higher).
CI=confidence interval.
Numbers in **bold** are significant.
ICC=intraclass correlation, sum; random effect variance / (random effect variance+ residual effect variance). Here the percentage is given which is the ICC*100%.

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# 4

# Impact of organized activities on mental health in children and adolescents: An umbrella review

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## ABSTRACT

Mental health problems are a leading cause of health-related disability among children and adolescents.

Organized activities are a possible preventive factor for mental health problems. An aggregated overview of evidence is relevant for youth policymakers and is lacking so far. Thus we aim to provide an overview of published systematic reviews and meta-analyses on the impact of participation in organized sport and non-sport activities (e.g. arts, music) on childhood and adolescent mental health. Systematic reviews were identified through a search in five databases (Embase, MEDLINE, Web of Science core collection, CINAHL and PsycINFO) on 25-March-2021. Systematic reviews about organized activities and mental health outcomes in 0-21-year-olds published in English were included. Two independent reviewers assessed titles, abstracts and full texts, performed data-extraction and quality assessment using the AMSTAR-2 and assessed the quality of evidence. Out of 833 studies, six were considered eligible. Quality of the reviews ranged from critically low to moderate. Most reviews focused on organized sport activities, focusing on: team sport, level of sport involvement, extracurricular and community sport activities. Indications of a positive impact on mental health outcomes were found for participation in team sport, in (school) clubs, and in extracurricular and community sport and non-sport activities. We found a small positive impact of organized sport activities on mental health outcomes among children and adolescents. This seems not to depend on any specific type of organized sport activity. Limited evidence was found for organized non-sport activities.

## INTRODUCTION

Mental health problems are a leading cause of health-related disability among children and adolescents.(1, 2) Worldwide, around 10-20% of all children and adolescents experience mental health problems.(3) Mental health problems during childhood or adolescence can also have implications in adulthood such as mental health problems or employment difficulties.(4-6) However, according to the World Health Organization (WHO) mental health is more than the absence of mental health problems. It is "a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to the community".(7) In a similar vein, Keyes suggests that absence of mental health (i.e. languishing), is not similar to good mental health (i.e. flourishing).(2, 8-12) Exploring possible preventive factors for reducing mental health problems and for promoting good mental health is thus important.

One possible factor for reducing mental health problems or promoting good mental health is participation in organized activities, whether sport or non-sport.(13, 14) The positive youth development theory, grounded in the socio-ecological systems theory, postulated that sport and non-sport organized activities may offer opportunities for children and adolescents to develop relationships, engage in activities that increase their confidence, competence, character, caring and connectedness.(15, 16) Consequentially it is hypothesized that they are at lower risk for academic, psychological, social and behavioral problems.(13, 14) This may depend on the type, breadth, intensity and duration of the activities.(14)

Organized sport and non-sport activities can be defined as activities that are structured, supervised by adults, emphasize skill building, are generally voluntary, have regular scheduled meetings and are not part of the school curriculum.(14, 17, 18) Examples of organized activities include but are not limited to sport, arts, music and community programs.(14, 17, 18) Features of organized activities that have been found to improve mental health are: safe and appropriate peer interactions, structure and adult supervision, forming of supportive relationships with peers and adults, emphasis on inclusion and a sense of belonging, emphasis on positive social norms, support of efficacy and mattering and skill-building.(19) Organized sport activities also includes physical activity as an additional feature that may improve the mental health of children and adolescents.(20) Organized non-sport activities may include physical activity but not always (e.g. scouting or dance). Local policies can influence and encourage participation in organized sport and non-sport activities and its determinants.

Several studies examined the impact of various types of organized sport and non-sport activities on aspects of child and adolescent mental health. These suggest a possible beneficial impact on mental health such as behavioral outcomes, self-esteem and self-confidence.(21, 22) Contrary, some studies have observed harmful consequences of organized activities, such as risk behavior and bullying.(23-26) In two of these studies this depended on the amount of time that was spend in the organized activities.(25, 26)

As far as we know, there currently is no overview aggregating the available evidence from systematic reviews on the impact of participation in organized sport and non-sport activities on child and adolescent mental health, while such an overview would be highly relevant for policymakers in designing more effective preventive youth policies. Thus, the aim of this study is providing an overview of the evidence of the impact of organized sport and non-sport activities on childhood and adolescent mental health outcomes from a public health perspective based on an umbrella review of published systematic reviews.

## METHODS

A protocol prospectively registered within PROSPERO (CRD42020213597, available via https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020213597) on November 9th 2020. The protocol was developed in accordance with the Preferred Reporting Items for systematic reviews and meta-analyses Protocol (PRISMA-P).(27) This umbrella review adheres to the PRISMA statement and used guidance from Arotomatis et al.(28, 29)

### Eligibility

Peer-reviewed systematic reviews with and without meta-analyses were considered eligible.(28) Other types of reviews (i.e. narrative or rapid reviews) were excluded as we aim to summarize studies with the highest level of evidence.(30)

Systematic reviews containing observational study designs (i.e. case-control, cohort, cross-sectional) and trial designs in any form including pilot studies were included. Qualitative designs were considered not eligible. Systematic reviews containing both quantitative and qualitative designs were included.

Systematic reviews containing studies with children and adolescents with a mean age between 0 and 21 years old were included.(31) Systematic reviews in which any participant was aged ≥25 years old without sub-analysis for participants aged <25 years

old with a mean age between 0-21 years old, were excluded. Systematic reviews on general populations were included, as well as reviews with sub-analyses on general populations. Systematic reviews that included studies on fully clinical or at-risk populations (e.g. attention deficit hyperactivity disorder (ADHD), traumatic experiences) were excluded as we aimed to study the impact of organized activities on mental health from a public health perspective.

Systematic reviews containing organized sport or non-sport activities were included. For this umbrella-review a definition based upon the definition postulated by Bohnert et al., was used.(14, 17, 32) Their definition is: "Organized activities is a blanket term that refers to a broad range of adult-sponsored activities that fall outside the regular school curriculum and include diverse contexts such as school-based extracurricular activities, community organizations, and youth development programs. Despite the differences in focus, organized activities share several common features. The activities are generally voluntary, hold regularly scheduled meetings, are supervised by adults, include other participants, are organized around particular competencies, and tend to be rule-based."(14, 17, 32) In this umbrella review we broaden this definition and include organized activities without other participants (e.g. individual arts or music lessons, individual resistance training) and organized activities that are not rule-based. Organized activities should be provided by a volunteering- or non-volunteering party (i.e. not organized by children or adolescents themselves)."

The control group or comparator condition is formed by children and adolescents not exposed to organized sport activities and/or non-sport activities (e.g. non- organized sport or non- sport activities, no sport or non-sport activities).

There were no limitations regarding country. Systematic reviews were included if they included organized activities occurring in an extracurricular (after-school) or community (e.g. clubs, community centers) setting corresponding with our definition. Systematic reviews focusing on sport or non-sport activities that took place within school-curricula or clinical settings were excluded.

The outcomes of interest were indicators of me mental health as defined by the WHO and by Keyes.(2, 7-12) The WHO defined mental health as follows: "mental health is more than the absence of mental health problems. It is a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to the community".(7) The definition of mental health by Keyes consists of three aspects: emotional well-being, psychological well-being and social well-being. According to Keyes absence of mental

health problems (i.e. languishing) is not similar to good mental health (i.e. flourishing) and mental health should be seen as a continuum.(2, 8-12) In line with these definitions we did not only include all (aspects of) mental health problems as indicators of mental health and thus as outcomes of interest (e.g. anxiety, depression, ADHD and other mental health problems), but also aspects of mental well-being (e.g. self-esteem, efficacy, self-worth). No preferred outcome measure was formulated a priori. Systematic reviews that did not report on at least one aspect of mental health were excluded.

Systematic reviews published in English were included. Systematic reviews in other languages were excluded because of language barriers of the authors.

## Search strategy

A systematic literature search was conducted in five databases (Embase.com, MEDLINE via Ovid, Web of Science core collection (See appendix A for our core collection), CINAHL via EBSCOhost and PsycINFO via Ovid) from inception to March 25$^{th}$ 2021 (date last searched). The search strategy was developed by a Medical Librarian (WMB) and combined thesaurus terms as well as terms in title abstract for three elements: sport or participation, mental health or behavior, children or adolescents, and was limited to systematic reviews and meta-analysis. The syntax and thesaurus terms of the search strategy were adapted to each distinct database. In the search strategy, no language or date limits were applied. Appendix A includes the full search strategy. References of relevant reviews were screened for other relevant systematic reviews.

## Selection process

Endnote X9 was used for the selection process. Duplicates of records were retrieved and removed using the method described by Bramer et al.(33) Two independent reviewers (MB and MS) performed title and abstract screening to identify eligible reviews and subsequently performed full-text screening. Disagreements at both stages were resolved through discussion until consensus was reached, and, if necessary, resolved by consulting a third independent reviewer (WJ).

## Data extraction

Data were extracted independently by two reviewers (MB and MS). Extracted information included: first author, year of publication, included languages of primary studies, objective, eligibility criteria, if it included a meta-analysis, number and type of primary studies, sample (size, age and sex), number of databases searched, range of publication date, instrument for quality appraisal and quality rating, intervention(s)/phenomena of interest, outcome(s) and outcome measure(s), measurement instruments and funding.

## Overlap

The corrected covered area (CCA) was used to calculate the amount of overlap of primary studies included in the systematic reviews.(34) The CCA is calculated by dividing the frequency of repeated occurrences of index studies (first occurrence of primary study) in other reviews by the product of the number of index studies and the number of reviews, minus the number of reviews. The CCA can be represented as a percentage between 0-100%. A CCA of 0-5% is considered slight overlap, a CCA of 6-10% is considered moderate overlap, a CCA of 11-15% is considered high overlap and a CCA >15 is considered very high overlap.(34) For the calculation, see appendix B.

## Risk of bias

Two reviewers (MB and MS) independently assessed risk of bias of the included systematic reviews using the A Measurement Tool to Assess Systematic Reviews (AMSTAR-2).(35) Discrepancies were resolved through discussion until consensus was reached and if necessary by consulting a third independent reviewer (WJ). The AMSTAR-2 consists of sixteen items. Seven items are considered critical, these are: a priori protocol, adequate search strategy, providing justification for excluded studies, appropriate risk of bias assessment, appropriate statistical methods in meta-analysis, accounting for risk of bias when interpreting results and publication bias. Three items concern meta-analytical methods and are not applicable for systematic reviews without meta-analysis. The AMSTAR-2 rates systematic reviews as: critically low (more than one critical weakness with or without non-critical weaknesses), low (one critical weakness with or without non-critical weaknesses), moderate (more than one non-critical weakness) or high quality (no or one non-critical weakness).(35)

## Analysis

Because of the broad scope of organized activities and mental health outcomes included in this umbrella review performing a meta-analysis was not possible. Results were narratively (qualitative and quantitative) synthesized. Results were grouped by type of organized activities (i.e. sport, non-sport or both) and further subdivided by type of organized sport activity. As meta-analyses used different effect sizes or measures of association, we converted all reported effect sizes and measures of association to the Cohen's d, for comparison purposes.(36, 37) Formulas for these conversions are reported in appendix C. For the summary of findings, quality of evidence per determinant was assessed by a self-developed decision scheme including: meta-analysis, number of primary studies, significance, direction, magnitude and imprecision. Scores were: no indication, mixed findings, insufficient evidence, there is an indication or high certainty. A self-developed scheme was used as suitable schemes for umbrella reviews are lacking (Appendix D).

## RESULTS

After deduplication, 833 records remained. After all rounds of screening six systematic reviews were considered eligible.(38-43) Figure 1 describes the results of the search and study selection process. Appendix E includes references (n=85) of all studies excluded after full-text screening subdivided by reason for exclusion.

Table 1a shows the characteristics of the six included systematic reviews. Systematic reviews were published between 2013-2020.(38-43) Four systematic reviews included meta-analyses.(38, 39, 42, 43) Sample sizes of the systematic reviews ranged from 460-234,503 participants. Databases searched ranged from 1-13. Included primary studies ranged from 7-113 studies. Most primary studies were from North America, followed by Europe and Australia. Five primary studies were from Asia and two from Africa. Primary studies were published between 1988-2020.

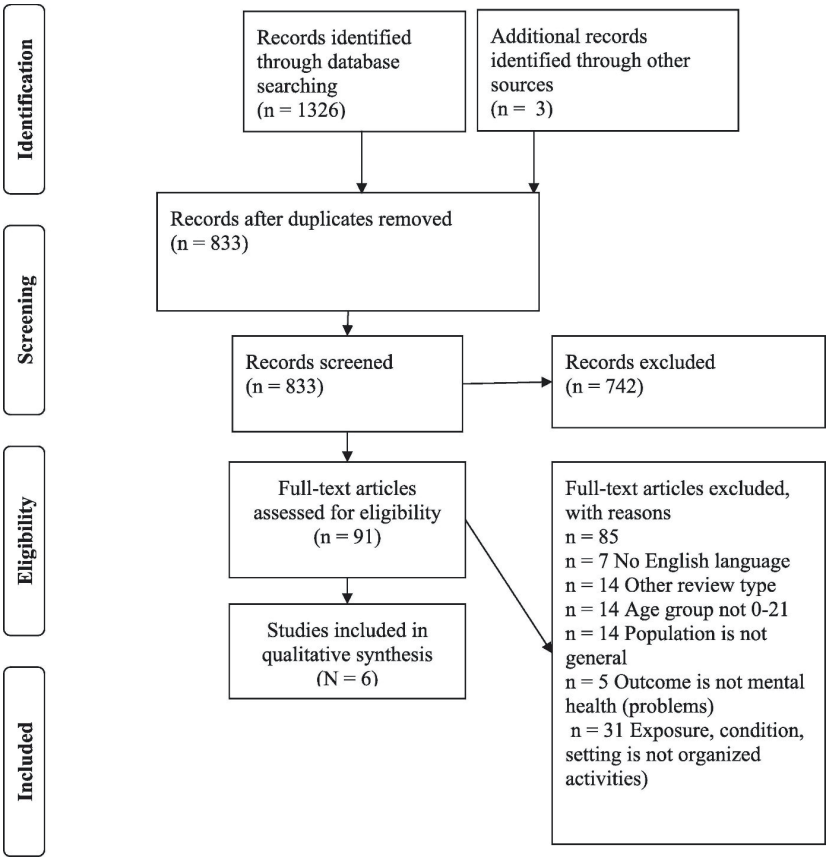


**Figure 1.** Flow diagram showing the selection process in the umbrella review.

**Table 1a.** Characteristics of included systematic reviews.

| Author & year | Type of review | Objective | Databases and data range of search | Sample size | Included studies (design, n) | Publication data range | Funding |
|---|---|---|---|---|---|---|---|
| Cairns, 2013 | $SR_a$ & $MA_b$ | To identify risk and protective factors that are associated with depression adolescents (between 12-18 $y_c$) with a focus on those factors that are potentially modifiable by the adolescent. | PsycINFO, PubMed, Scopus (n=3).<br><br>Inception-Sept 2013. | n=234,503 | SR: n=113<br>MA: n=69<br><br>Longitudinal (n=113). | 1986-2013 | Australian Postgraduate Award from the Australian Federal Government. National Health and Medical Research Council Australia Fellowship (566652) |
| Collins, 2019 | SR & MA | To investigate the effect of $RT_d$ interventions on 'the self' in youth. | Embase, ERIC, MEDLINE, PsycINFO, PubMed, SCOPUS, SPORTDiscuss (n=7).<br><br>Inception-Oct 2018. | SR: n=460<br>MA: n=375 | SR: n=7<br>MA: n=4<br><br>Pre-post design (n=7). | SR: 1988-2017<br>MA: 2010-2015 | No |
| Eime, 2013 | SR | a) To investigate the psychological and social benefits of participation in sport for children and adolescents, b) To develop a conceptual model. | AU SPORT, AusportMed, CINAHL, Cochrane Library, EBSCHOHost Research Databases, Health Collection, Informit, Medline Fulltext, PsycARTICLES, Psychology and Behavioral Sciences Collection, PsycINFO, PubMed, Scopus, SPORTDiscus Fulltext (n=14).<br><br>Jan 1990-May 2012. | n=143,489 | SR: n=30.<br><br>Longitudinal (n=9)<br>Cross-sectional, quantitative (n=21; of which 2 qualitative). | 1993-2011 | VicHealth Research Practice Fellowship. |

**Table 1a.** Characteristics of included systematic reviews. (Continued)

| Author & year | Type of review | Objective | Databases and data range of search | Sample size | Included studies (design, n) | Publication data range | Funding |
|---|---|---|---|---|---|---|---|
| Evans, 2016 | SR | To investigate the psychological and social benefits of participation in sport for children and adolescents. | CINAHL, ERIC, MEDLINE, PsycINFO, SPORTDiscus (n=5).<br><br>Jan 1980-May 2016. | n=35,257 | SR: n=35<br><br>Longitudinal (n=12).<br>Cross-sectional (n=19).<br>Other (n=4). | 1995-2016 | No |
| Panza, 2020 | SR & MA | To investigate the correlation between mental health and organized sport participation among adolescents aged 12–18 y. | ERIC, MEDLINE, PsycINFO, SPORTDiscus ,Web of Science (n=5).<br><br>Inception-Oct 2018. | SR: n=110,054<br>MA: unclear | SR: n=28<br>MA: n=20<br><br>Longitudinal (n=16).<br>Cross-sectional (n-13). | 2000-2019 | unclear |
| Zuckerman, 2020 | SR & MA | To assess the association between team sport participation and health outcomes in young, school-aged athletes from ages 5- to 25-years old. Health outcomes were divided into three domains: 1) behavioral, 2) psychological or 3) social. | PubMed (n=1) | SR: n=106,887<br>MA: n=52,122 | SR: n=34<br>MA: n=9<br><br>Design: unclear. | 1996-2020 | No |

**Table 1b.** Characteristics of included systematic reviews.

| Author & year | Setting | Population characteristics: Age range, Sex (% girls), and Other | Continents | Quality assessment, assessed quality | Condition | Comparison | Mental health outcome(s) | Measurement tool(s) |
|---|---|---|---|---|---|---|---|---|
| Cairns, 2014 | Organized sport & extra-curricular activities | Age: 12-18 $y_{mm}$<br>Sex: unclear<br>Other: general population. | North America n=81, Australia n=10, Europe n=19, Asia n=3. | unclear | Extracurricular activities defined as the extent to which the adolescent is involved in activities that occur outside or parallel to the traditional school curriculum (e.g. clubs, teams, volunteering) & Sport defined as involvement in organized sport (individual or team based). | unclear | The onset of unipolar depressive disorders as classified in the DSM-IV-$R_e$ | NIMH-$DIS_f$, CES-$D_g$, CES-$DC_h$, $MDI_i$, $CDI_j$, self-developed. |
| Collins, 2019 | Community sport & extra-curricular activities | Age: 10-16 $y_{nn}$<br>Sex: SR:52.5%<br>Other: general/ healthy n=2, mixed n=3, overweight/ obese n=2. | North America n=5, Australia n=2. | Quality Assessment Tool for Quantitative Studies<br><br>n=2; 28.6% regarded as high quality | RT methods, excluding studies with resistance training methods containing plyometric, vibration or neuromuscular training, training specifically for rehabilitation purposes or additional activity. | No resistance training, nutrition input only, normal activity, PE | Perceived body attractiveness, global self-worth, physical self-worth | M-$ZSCSC_k$, $PSE_l$, Adapted $CSES_m$, CY-$PSPP_n$, CY-$PSPP_n$ adolescents, Exercise $SEQ_o$, $PSW_p$ , CY-PSPP Self-Esteem sub-$scale_q$' modified $RT_d$ Self-efficacy, modified $RT_d$ Outcome Expectancy Questionnaire, self-developed. |

**Table 1b.** Characteristics of included systematic reviews. (Continued)

| Author & year | Setting | Population characteristics: Age range, Sex (% girls), and Other | Continents | Quality assessment, assessed quality | Condition | Comparison | Mental health outcome(s) | Measurement tool(s) |
|---|---|---|---|---|---|---|---|---|
| Eime, 2013 | unclear | Age: 6-12 $y_{nn}$<br>Sex: unclear<br>Other: unclear | North America n=25, Europe n= 5. | Downs and Black tool<br><br>n=10 (33%) in the highest tertile. | Participation in sport. Sport defined as a human activity of achieving a result requiring physical exertion and/or physical skill which, by its nature and organization, is competitive and is generally accepted as being a sport (i.e. as team sport, extracurricular activity, school/club sport, level of sport involvement, sport) | No sport, other PA, less/no team sport, other EA, other OA, recreation sport participation, other structured an unstructured activities, less or no school sport, non-sport club member, non-sport participation | Risk of depression and mental ill health, developmental aspects/ behavior, social anxiety and shyness, self-esteem, suicidal behavior. | unclear |

**Table 1b.** Characteristics of included systematic reviews. (Continued)

| Author & year | Setting | Population characteristics: Age range, Sex (% girls), and Other | Continents | Quality assessment, assessed quality | Condition | Comparison | Mental health outcome(s) | Measurement tool(s) |
|---|---|---|---|---|---|---|---|---|
| Evans, 2016 | Community sport & extra-curricular sport | Age: 7-20 $y_{nn}$<br>Sex: 51.5% (computed based on 33/35 studies<br>Other: unclear | North America n=17, Australia n=3, Europe n=8, Asia n=1, Africa n=1. | Downs and Black tool, adapted version<br><br>n=25 (71.4%) had an average risk of bias score. | Organized sport defined as competitive activity requiring skill coordination and/or exertion - generally accepted as being 'sport'. Also includes features that distinguish it as organized (e.g. Regular participation schedule, rule-guided, adult leaders, and social commitment). | Different activity types or different levels of an activity. | Psychosocial health and well-being, sport-specific or general self-concept, moral beliefs, development of positive assets, sport-specific motives and intentions and sport group environments. | Item created to assess sport enjoyment from the $RSES_q$, $CES\text{-}D_g$, parent-reported $ESAK_r$, items assessing intentions to return from $SCM_s$, $WHO\text{-}5_t$, parent-reported $HRQOL_u$ , social and task interdependence subscales $YES_v$, Self-developed and some not reported. |
| Panza, 2020 | Community sport & school-based sport | Age: 11.5-17.7 $y_{nn}$<br>Sex: 52.9%<br>Other: unclear | North America n=19, Australia n=3, Europe n=6, Africa n=1. | Downs and Black tool, adapted version<br><br>n=24 (82.8%) regarded as having a relatively low risk of bias. | Sport participation defined as a type of physical and competitive OA that is played on a team or as an individual and shaped by facilities, policies, and normative beliefs that the activity is seen as a sport. | No sport involvement or no/low frequency. | Anxiety symptoms and Depression symptoms. | $BDI_w$, $BDI\text{-}II_w$, $CDI_j$, $CES\text{-}D_g$, $CES\text{-}DC_g$,$CIDI_x$, $DASS_y$, $GHQ\text{-}12^z$, $HADS_{aa}$, $MDI_i$, $PHQ\text{-}9_{bb}$, $SCL\text{-}90(R)_{cc}$, $SMFQ_{dd}$, $CCHS_{ee}$, $SCAS_{ff}$, $STAI_{gg}$, Zung $SAS_{hh}$, some not reported. |

**Table 1b.** Characteristics of included systematic reviews. (Continued)

| Author & year | Setting | Population characteristics: Age range, Sex (% girls), and Other | Continents | Quality assessment, assessed quality | Condition | Comparison | Mental health outcome(s) | Measurement tool(s) |
|---|---|---|---|---|---|---|---|---|
| Zuckerman, 2020 | Team sport | Age: 5-25 $y_{mm}$<br>Sex: Unclear<br>Other: Unclear | North America n=20, Europe n=12 (n=1 is from Australia and Czech republic), Asia n=1. | ROBINS-I<br><br>n=32 (94%) of the studies were regarded as having a low risk of bias. | Team sport participation | No team sport participation (i.e. individual or no sport participation) or none | Behavioral, psychological and social health outcomes (such as anxiety/ depressive symptoms). | Anxiety: GAD-$7_{ii}$ and self-reported;<br>Depression: Beck depression inventory second edition and self-reported;<br><br>Self-worth: $WSDQ_{jj}$;<br>Psychosocial health: $SDQ_{kk}$;<br>Social behavior: $SBI_{ll}$;<br>Self-esteem: self-reported and other<br>Anorexia nervosa: ORTO-15;<br>Quality of Life: KIDSCREEN-52;<br>Delinquency & life satisfaction: self-reported 7-point life satisfaction scale<br>Social identity: self-reported twelve-item 7-point scale assessing cognitive centrality, in-group ties and in-group affect<br>High risk activity: other |

[a]SR=systematic review; [b]MA=Meta=analysis; [c]y=years; [d]RT=resistance training; [e]DSM-IV-R = Diagnostic and Statistical Manual of Mental Disorders Revised; [f]NIMHH-DIS=National Institute of Mental Health Diagnostic Interview Schedule; [g]CES-D=Center for Epidemiological Studies Depression Scale; [h]CES-DC=Center for Epidemiological Studies Depression Scale for Children; [i]MDI=Major Depression Inventory; [j]CDI=Children's Depression Inventory; [k]M-ZSCSC=The Martinek Zaichkowsky Self-concept Scale for Children; [l]PSE=Physical Self-Efficacy Scale; [m]CSES=Children' s Self Efficacy Scale; [n]CY-PSPP=Physical Self-Perception Profile for Children and youth; [o]SEQ=Self-efficacy Scale; [p]PSW=Physical Self Worth Scale; [q]RSES=Rosenberg Self-Esteem Scale;[r]ESAK=Social Anxiety in Children and Adolescents; [s]SCM=Sport Commitment Questionnaire; [t]WHO-5=WHO-5 Well-Being Index;[u]HRQOL= Health Related Quality of Life; [v]YES=Youth Experience Survey 2.0; [w]BDI=Beck Depression Inventory;[x]CIDI=Composite International Diagnostic Interview;[y]DASS=Depression Anxiety Stress Scales;[z]GHQ-12=General Health Questionnaire-12;[aa]HADS=Hospital Anxiety and Depression Scale;[bb]PHQ-9=Patient Health Questionnaire-9; [cc]SCL-90(R)=Symptom Checklist-90-Revised;[dd]SMFQ=Short Mood and Feelings Questionnaire;[ee]CCHS=Canadian Community Health Survey;[ff]SCAS=Spence Children's Anxiety Scale;[gg]STAI=State-Trait Anxiety Inventory;[hh]Zung SAS=Zung Self-Rating Anxiety Scale;[ii]GAD-7=Generalized Anxiety Disorder;[jj]WSDQ=Washington self-description questionnaire;[kk]SDQ=Strengths and Difficulties questionnaire;[ll]SBI=Sports Behavior Inventory.
[mm]Based on inclusion criteria. [nn]Based on included primary papers for which age was reported.

All six systematic reviews reported on organized sport activities and two also reported on organized non-sport activities.(38, 40) Five systematic reviews examined individual and team-based sport.(38, 40-43) Three systematic reviews examined level of sport involvement.(40-42) Two systematic reviews focused on extracurricular school and community non-sport activities and sport.(40, 41) One examined resistance training.(39) One examined organized non-sport activities.(38) One examined (school) club sport and non-specified sport.(40) One examined non-specified sport.(40)

Table 1b shows all mental health outcomes studied in the included systematic reviews. Most studied mental health outcomes were (aspects of) mental health problems such as depressive symptoms and anxiety symptoms.(38, 40, 42, 43) Less studied were aspects of mental well-being such as development of positive assets, self-esteem, self-worth and self-concept.(39-41)

In total 17 studies out of 118 relevant primary studies were reported in multiple systematic reviews (14.4%). Three primary studies were reported thrice in the included systematic reviews.(44-46) The CCA amounting 3.6% indicates a slight overlap. Appendix B shows the citation matrix used to calculate the overlap.

Table 2 reports the quality assessment. Five systematic reviews were identified as critically low.(38, 39, 41-43) One systematic review was identified as moderate in quality.(40) Common quality lowering items were lack of reporting funding in primary studies (6/6), lack of an a priori protocol (5/6), lack of a description of excluded studies (5/6). Report of funding of the primary studies is needed to assess possible bias such as changes in the design, analyses or conclusion in favor of the interests of the funder.(47) An a priori protocol helps researchers conducting their review as it has been planned and reduces arbitrary decision-making.(48) An a priori protocol also enables readers to identify deviations from the planned methods and selective outcome reporting.(27) Justification for excluding studies is needed to examine the impact of their exclusion from the review.(35)

Table 3 and 4 provide meta-analysis and qualitative results, summarized findings and the quality of evidence.

Five systematic reviews reported results on team-based and individual sport participation.(38, 40-43) Three of these reported meta-analysis results of the impact of team-based and individual sport participation on mental health outcomes.(38, 40, 42) These mental health outcomes were either depressive symptoms, anxiety or a combination.(38, 40, 42) Summarized, a significant positive impact on mental health outcomes was

**Table 2.** Quality assessment using the AMSTAR-2.

| | | Cairns, 2014 | Collins, 2019 | Eime, 2013 | Evans, 2016 | Panza, 2020 | Zuckerman, 2020 |
|---|---|---|---|---|---|---|---|
| Item 1 | PICO components | No | Yes | No | Yes | No | Yes |
| **Item 2[a]** | A priori protocol | No | No | No | No | Partial yes | No |
| Item 3 | Study design | Yes | No | No | No | Yes | No |
| **Item 4[a]** | Search strategy | Partial yes | Partial yes | Partial yes | Partial yes | Partial yes | No |
| Item 5 | Study selection | No | Yes | No | No | Yes | Yes |
| Item 6 | Data extraction | Yes | No | No | Yes | Yes | Yes |
| **Item 7[a]** | Excluded studies | No | No | No | Yes | No | No |
| Item 8 | Description of included studies | No | No | Partial yes | Partial yes | Yes | No |
| **Item 9[a]** | RoB assessment | No | Partial yes | Partial yes | No | No | Yes |
| Item 10 | Reported funding | No | No | No | No | No | No |
| **Item 11[a]** | Meta-analyses methods | Yes | No | NA[b] | NA[b] | Yes | Yes |
| Item 12 | Assess impact RoB on results meta-analysis | No | Yes | NA[b] | NA[b] | No | Yes |
| **Item 13[a]** | Account for RoB in interpreting/discussing of results | No | Yes | Yes | Yes | No | No |
| Item 14 | Explanation of heterogeneity | No | Yes | Yes | Yes | Yes | Yes |
| **Item 15[a]** | Publication bias | Yes | Yes | NA[b] | NA[b] | Yes | No |
| Item 16 | Conflict of interest | Yes | Yes | Yes | Yes | No | Yes |
| **Overall score** | **Quality of the review** | **Critically low quality review** | **Critically low quality review** | **Moderate quality review** | **Critically low quality review** | **Critically low quality review** | **Critically low quality review** |

[a]Indicates a critical item on the AMSTAR-2; also shown in bold; [b]NA indicates not applicable i.e. no meta-analysis conducted.

Rating was as follows: high quality of review: No or one non-critical weakness, Moderate quality of review: More than one non-critical weakness, Low quality of review: One critical flaw with or without non-critical weaknesses, Critically low quality of review: More than one critical flaw with our without non-critical weaknesses.

PICO=population, intervention/exposure, control/comparator, outcome; RoB=Risk of Bias.

found. However, the magnitude of the effect estimate of the mental health outcomes was negligible or small (i.e. reduced anxiety/depressive symptoms). The heterogeneity was either moderate or high. Three systematic reviews reported qualitatively on the impact of team-based sport on mental health outcomes.(40, 41, 43) The qualitative synthesis

**Table 3.** Summarized findings of meta-analysis results and quality of evidence of included systematic reviews.

| Author, year | Primary studies used (n/total) | Results | Equivalent Cohen's D effect size | Magnitude of effects | Heterogeneity ($I^2$) | Significant $(Y/N)_a$ | Summary of findings and quality of evidence |
|---|---|---|---|---|---|---|---|
| | | **Sport organized activities** | | | | | |
| | | *Team-based and individual sport* | | | | | |
| Cairns, 2014 | 5/113 | Depressive symptoms: r = -0.046 (95%CI -0.083, -0.008) | -0.092 | No or negligible | Moderate (53.1%) | Y | There is an indication of a positive impact on mental health outcomes by team sport participation. |
| Panza, 2020 | 14/29 | Depressive symptoms: ρ = −0.08 (95%CI −0.10, −0.06). | -0.161 | No or negligible | High (80.7%) | Y | |
| Panza, 2020 | 9/29 | Anxiety: Anxiety: ρ = −0.12 (95% CI −0.15, −0.10). | -0.242 | Small negative | Moderate (71.2%) | Y | |
| Zuckerman, 2020 | 5/34 | Depressive symptoms/anxiety: OR = 0.59 (95%CI 0.54-0.64) | -0.291 | Small negative | High 97.7% | Y | |
| | | *Level of sport involvement (i.e. frequency)* | | | | | |
| Panza, 2019 | 12/29 | Depressive symptoms: ρ = −0.09 (95%CI −0.11, −0.06) | -0.181 | No or negligible | High (88.9%) | Y | There is an indication of a positive impact on mental health outcomes by a higher level of sport involvement. |

**Table 3.** Summarized findings of meta-analysis results and quality of evidence of included systematic reviews. (Continued)

| Author, year | Primary studies used (n/total) | Results | Equivalent Cohen's D effect size | Magnitude of effects | Heterogeneity ($I^2$) | Significant (Y/N)[a] | Summary of findings and quality of evidence |
|---|---|---|---|---|---|---|---|
| | | *Resistance training* | | | | | |
| Collins, 2019 | 4/7 | Physical self-worth: Hedges' g = 0.319 (95%CI 0.114, 0.523) | 0.319 | Small positive | Small to moderate (0-44.9%[2]) | Y | There are mixed findings (small positive effects but not all significant) regarding the impact on mental health outcomes by participating in resistance training. |
| Collins, 2019 | 3/7 | Perceived body attractiveness: Hedges' g = 0.211 (95% CI -0.031, 0.454) | 0.211 | Small positive | Small to moderate (0-44.9%[2]) | N | |
| Collins, 2019 | 3/7 | Global self-esteem: Hedges' g = 0.409 (95%CI 0.149, 0.669) | 0.409 | Small positive | Small to moderate (0-44.9%[2]) | Y | |
| | | **Non-sport organized activities** | | | | | |
| | | *Extracurricular non-sport activities* | | | | | |
| Cairns, 2014 | 8/113 | Depressive symptoms: r = -0.026 (95%CI -0.122, 0.970) | -0.052 | No or negligible | High (97.4%) | N | There is no indication of an impact on a mental health outcomes by participating in extracurricular activities. |

[a]Statistical significance defined as a p-value <0.05, =significant, N=non-significant.; [2] No individual $I^2$ was reported.
Reported associations and effect sizes were transformed to Cohen's D effect sizes. The magnitude of Cohen's D was interpreted using Cohen's D conversion. Heterogeneity was assessed using the $I^2$ statistic. For interpretation, $I^2$ values of 25%, 50% and 75% were considered to indicate low, moderate and high heterogeneity. Summary of findings and quality of evidence is based on a self-developed decision scheme to assess the quality of evidence.

**Table 4.** Summarized findings of qualitative results and quality of evidence of included systematic reviews.

| Author, year | Primary studies used (n/total) | Results as extracted from systematic reviews | Summary of findings and quality of evidence |
|---|---|---|---|
| | | **Sport organized activities** | |
| | | *Sport non-specified* | |
| Eime, 2013 | 4/30 | There were findings that sport was associated with enhanced self-concept, lower rates of suicidal ideation (including thoughts and intentions), and with positive adjustment (e.g. social skills and self-esteem). | There is an indication of a positive impact on mental health outcomes by participating in no further specified sport activities. |
| | | *Level of sport involvement (e.g. frequency, duration, intensity, early involvement)* | |
| Eime, 2013 | 5/30 | There were findings that greater sport participation was associated with lower risk of emotional distress and with lower levels of emotional and social problems. Also moderate sport participation was associated with lower depression scores. Greater participation in formal compared to informal sport was associated with lower levels of emotional and social problems. Greater frequency in sport participation led to better feelings of well-being compared to lower frequency. Total number of sport and years involved in sport was associated with better physical appearance and physical competence. Differences between competitive or non-competitive sport were minimal. | |
| Evans, 2017 | 16/35 | There were findings for an association of early sport involvement and amount of sport involvement with psychosocial outcomes (depression and self-esteem). There was insufficient evidence for amount of individual deliberate practice or specialization in sport due to limited research. | |
| Panza, 2020 | 3/29 | There were findings that duration of sport participation may have a small inverse correlation with depression symptoms. | |
| | | *Resistance training* | |
| Collins, 2019 | 3/7 | There were findings that support a positive effect of resistance training on some constructs of 'the self '. There was a significant increase in total self-efficacy. No evidence for a positive effect of resistance training on self-concept. | There are mixed findings regarding the impact on mental health outcomes by participating in resistance training. |

**Table 4.** Summarized findings of qualitative results and quality of evidence of included systematic reviews. (Continued)

| Author, year | Primary studies used (n/total) | Results as extracted from systematic reviews | Summary of findings and quality of evidence |
|---|---|---|---|
| | | *Team-based sport* | |
| Eime, 2013 | 8/30 | There were findings of mental health benefits (e.g. lower general risk-taking, fewer mental and general health problems, positive associations with social acceptance and self-esteem and negative associations with depressive symptoms, social isolation and mood) by participation in team-based sport. There were also findings that it was protective against feelings of hopelessness and suicidality and that it increased life satisfaction. | There are mixed findings regarding the impact on mental health outcomes by participating in team-based sport. |
| Evans, 2017 | 14/35 | There were findings of a positive association of participation in team-based sport to psychosocial outcomes (such as youth development experiences, moral reasoning, depression and self-esteem). Some studies reported null differences regarding depressive symptoms or anxiety. | |
| Zuckerman, 2020 | 23/34 | The majority of studies supported a positive impact of team sport participation on many behavioral and psychological health outcomes. Additional studies found similarly positive effects such as less physical fighting. | |
| | | *(School) club sport* | |
| Eime, 2013 | 5/30 | There were findings of higher scores on social functioning and mental health by participating in school and club sport. There were also findings of an association with superior well-being (including being better adjusted) feeling less nervous or anxious, being more often full of energy and happy about their life, feeling sad or depressed less often, having higher body image and fewer suicidal attempts. School sport participation was associated with self-esteem. A lower frequency of mental health problems by participation in competitive sport was also found. | There is an indication of a positive impact on mental health outcomes by participating in (school) club sport. |
| Evans, 2017 | 2/35 | There were findings of an association of extracurricular school or community sport with psychosocial outcomes. | |

**Table 4.** Summarized findings of qualitative results and quality of evidence of included systematic reviews. (Continued)

| Author, year | Primary studies used (n/total) | Results as extracted from systematic reviews | Summary of findings and quality of evidence |
|---|---|---|---|
| | | *Other sport* | |
| Evans, 2017 | 5/35 | Insufficient evidence for an association of contact sport, adult involved sport, or participation in sport that require leanness or aesthetic judgements with psychosocial outcomes. | There is insufficient evidence for an impact of other sport on mental health outcomes by participating in other categories of sport studied. |
| | | **Sport and non-sport organized activities** | |
| | | *Extracurricular school and community non-sport activities and sport* | |
| Eime, 2013 | 8/30 | There were findings that structured activities (sport and non-sport) led to higher positive functioning. Children participating in sport and clubs had higher social skill scores compared to children who did not participate in outside-school activities. Participation in sport and non-sport organized activities led to the greatest youth development outcomes. Sport participation led to more developmental benefits than other types of extracurricular activities but the greatest benefits were seen for sport and non-sport extracurricular activities combined. Sport participation alone and in combination with non-sport activities was associated with better health outcomes, including higher healthy self-image, lower risk of emotional distress, suicidal behavior and substance abuse. There were also findings that it led higher rates of negative peer-interaction, higher rates of self-knowledge and better emotional regulation. | There is an indication of a positive impact on mental health outcomes by participating in extracurricular and community non-sport activities and sport. |

Summary of findings and quality of evidence is based on a self-developed decision scheme to assess the quality of evidence.



of team-based sport yielded mixed findings on mental health outcomes.(40, 41, 43) The mixed findings were due to some studies that found no positive or negative impact (null effect). Many different mental health outcomes were studied in the qualitative analysis. (40, 41, 43)

Three systematic reviews reported results regarding level of sport involvement.(40-42) Level of sport involvement included frequency, a longer period/duration of sport involve-

ment, intensity and involvement in sport at an early age.(40-42) One systematic review reported meta-analysis results of the frequency of sport involvement with depressive symptoms as mental health outcome.(42) Results from this review showed that there was evidence for an impact on mental health outcomes but with a negligible magnitude of effect and high heterogeneity.(42) Qualitatively, findings from three systematic reviews showed a positive impact of a higher frequency, greater intensity, a longer period/duration of sport involvement and involvement at an early age (i.e. during childhood) on mental health outcomes.(40-42)

Two systematic reviews reported results regarding extracurricular activities.(38, 40) One systematic review reported meta-analysis results of non-sport extracurricular activities with depressive symptoms as mental health outcome.(38) Findings showed no impact of extracurricular non-sport activities on mental health outcomes as the meta-analysis yielded a non-significant result.(38) One systematic review reported qualitative results of extracurricular non-sport and sport school and community activities with mental health outcomes.(40) Findings showed a positive impact on mental health outcomes such as higher self-image, lower risk of emotional distress, better emotional regulation and psychosocial outcomes.(40) This systematic review also reported that sport participation showed greater benefits than extracurricular non-sport activities and that a combination showed greatest benefits.(40)

For resistance training, sport non-specified, (school) club sport, and other sport one systematic review reported results regarding mental health outcomes.(39-41) Meta-analysis and qualitative findings of resistance training on mental health outcomes were mixed.(39) Qualitative findings reported insufficient evidence for an impact on mental health outcomes from other sport and a positive impact on mental health outcomes from sport non-specified and (school) club sport. A small number of primary studies were included.(40, 41)

## DISCUSSION

This umbrella review provides a detailed overview and shows that there may be a small positive impact on mental health in children and adolescents by participating in organized sport activities. Relatively much eligible research about organized sport activities and relatively less about organized non-sport activities with mental health in children and adolescents was found.

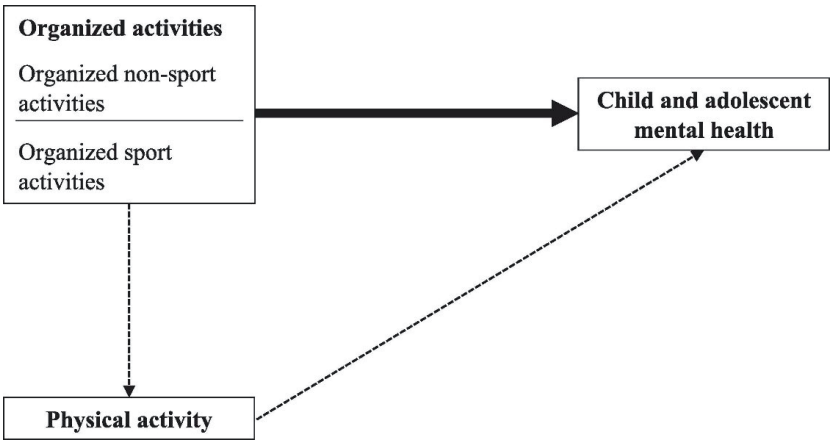


**Figure 2.** Associations of interest for this umbrella review.
The bold arrow indicates the impact of organized activities on child and adolescent mental health outcomes based on literature that was used for this umbrella review. The other two arrows indicate possible hypothesized pathways based on previous literature and were not studied in this umbrella review. Definitions of organized activities and mental health are given in the methods.

The objective of our umbrella review was to provide an overview of the evidence of the impact of organized sport and non-sport activities on child and adolescent mental health from a public health perspective. Figure 2 shows the associations of interest for our umbrella review. Outside of the scope of our umbrella review and thus not studied are the association of participating in organized activities with physical activity and the association of physical activity with child and adolescent mental health. For the association of physical activity with child and adolescent mental health evidence of a positive impact was provided in the umbrella review of Biddle and Asare.(20) None of the systematic reviews included in our umbrella review had an objective similar to our own objective; all addressed different research questions. Cairns et al., conducted a systematic review to different modifiable risk and preventive factors associated with depression.(38) Individual and team-based sport and extracurricular activities were included as possible preventive factors and were discussed broadly.(38) Furthermore, Collins et al., and Zuckerman et al., both focused on one type of organized sport activities (i.e. resistance training and team-based sport).(39, 43) The other three systematic reviews focused on several types of organized sport activities and included aspects relevant for our objective such as distinguishing between different settings and patterns of involvement.(40-42) None of the systematic reviews particularly aimed to study organized non-sport activities but in two systematic reviews it was reported.(38, 40) Overall, the systematic reviews reported a positive impact of organized sport activities on mental health although some negative or null results were found. Most studied mental health outcomes were (aspects of) mental health problems.

Six systematic reviews examined the impact of organized sport activities and there may be a small positive impact on child and adolescent mental health. However, effect sizes were negligible/small and heterogeneity between studies was high thus these findings need to be interpreted with caution. According to the positive youth development theory, children and adolescents can benefit from organized activities because they can develop relationships and engage in activities increasing their confidence, competence, character, caring and connectedness.(13, 15, 49-52) Many types of organized sport activities are included in our umbrella review and findings regarding mental health were generally in the same direction. Unfortunately, we cannot disentangle the impact of participating in organized sport activities from physical activity. None of the reviews has reported on this possible confounding or mediation, and most primary studies did not adjust for physical activity. Moreover, we cannot exclude the possibility that good mental health leads to participation in organized sport activities.(53) Further, self-selection or drop-out could possibly also lead to a seemingly better mental health among children and adolescents who participate in organized sport activities.

The positive impact of participating in organized sport activities was hypothesized to be dependent on the breadth, intensity, and duration of participation by Bohnert et al.(14) Findings from the systematic reviews were somewhat mixed. We found evidence that children and adolescents who participated more frequently, who participated with higher intensity or who participated with longer duration (e.g. started at an early age or participated for a long period), had better mental health compared to their peers.(40-42) However, the magnitude of the effect sizes were negligible.(40-42)

We found no systematic review reporting exclusively on the impact of organized non-sport activities on mental health in children or adolescents. Only two systematic reviews reported on both organized sport and non-sport activities in relation to mental health among children and adolescents.(38, 40) We are uncertain whether this is a gap in the literature due to scarcity of primary studies or that primary studies were not aggregated into systematic reviews. We found some systematic reviews that reported on organized non-sport activities that we excluded during the screening process. These reviews reported on yoga and mental health in clinical populations and not general populations or did not fit in our definition of organized activities, for instance because yoga was implemented as treatment.(54-57) Systematic reviews about group/choir singing and recreational rhythm music making in adults reported a positive impact on mental health outcomes.(58-60) A recent umbrella review on performing arts, partly in the form of organized activities, in relation to many outcomes among adults also reported mixed findings regarding mental health outcomes.(61) This corresponds with the systematic reviews included in our umbrella review that yielded mixed findings on the impact of

organized non-sport activities with mental health.(38, 40) The mixed findings could be because of a large variety in different organized non-sport activities. More systematic reviews and possibly more primary studies to examine the role of organized non-sport activities in relation to mental health in children and adolescents are needed due to the scarce available literature.

Most primary studies were performed in high-income countries. High-income countries have a large availability and variety in organized activities. Availability, affordability, transportation and cultural factors could affect participation.(19) Contextual factors may influence the impact of organized activities on mental health in children and adolescents. In low and middle-income countries (LMICS) this may be different. Findings of this umbrella review may not be generalizable to LMICS. The included systematic reviews did not report differences regarding age or socioeconomic status. That no differences were reported does not imply that there are no differences. Caution is needed when generalizing these findings.

All but one systematic review received a critically low quality score by the AMSTAR-2. The AMSTAR-2 tool is stringent and rates systematic reviews as low quality in case of one critical weakness and as critically low in case of two critical weaknesses.(35) Five systematic reviews have not explicitly mentioned an a priori protocol or deviated from their protocol and have not provided a detailed overview of excluded studies (with justification) at the stage of full text screening. Both critical weaknesses led to the critically low quality scores on the AMSTAR-2. If an a priori protocol or deviations were not mentioned this does not automatically mean that the study is biased, only that we do not know if it is. Providing an overview of excluded primary studies with justification shows readers that bias due to unjustified exclusion is not likely, and may increase the quality of systematic reviews. There is uncertainty regarding the bias of the systematic reviews but the results are consistent thus we feel confident about the findings. Confirmation of the reported results is needed. We emphasize the importance of adhering to the PRISMA guidelines.(29)

There is limited guidance on how to assess quality of evidence of outcome data in umbrella reviews.(62, 63) Some umbrella reviews used the GRADE-tool (Grading of Recommendations, Assessment, Development, and Evaluation).(63) This tool was developed for systematic reviews. For umbrella reviews the GRADE-tool could be applied by extracting the GRADE-assessment of primary studies.(63) If GRADE-assessment was not applied in the systematic reviews it is not possible to use the GRADE-tool in the umbrella-review. (63) For our umbrella review we used a self-developed decision scheme to assess the quality of evidence. We call for further development of guidance on how to assess the

quality of evidence when conducting an umbrella review. Our decision scheme in the appendix might serve as a first contribution.

## Study limitations and strengths

This umbrella review has several strengths. We included systematic reviews about a variety of organized sport activities. We used a comprehensive search strategy and two researchers independently performed the selection process, data extraction and quality assessment. We included 118 primary studies with a low degree of overlap in the included systematic reviews. This indicates no unnecessary duplication of systematic reviews.(34) Rather that the included systematic reviews complemented each other. We carefully examined the quality of the included systematic reviews and were able to elicit important issues of published systematic reviews. We used a wide definition of mental health, as our objective was to aggregate all evidence about the impact of organized activities on mental health outcomes. We used a wide age range to ensure we did not miss any studies to children and adolescents. This umbrella review also has some limitations. For this umbrella review only systematic reviews with and without meta-analysis were considered eligible as these types of reviews provide the highest level of evidence. Consequently, this led to the exclusion of possibly relevant systematic searches or systematized qualitative, state-of-the art, narrative, mixed methods, overviews, rapid and scoping reviews.(64) Findings of this umbrella review are dependent on the data and that has been synthesized and reported by the included systematic reviews. Some data were lacking in the included systematic reviews. It is unclear if this is due to data lacking in primary studies. Moreover, we have not found systematic reviews that studied a negative impact of organized activities on child or adolescent mental health. We have not restricted our search to positive outcomes of mental health. That we did not find any systematic review that studied the negative impact on mental health could be due to a focus on positive mental health outcomes in previous studies and to little focus on possible negative mental health outcomes. In the included systematic reviews most studies found a positive impact or null results whereas only a few reported a negative impact. However, earlier studies have postulated that too much participating in organized activities could lead to negative outcomes on mental health such as stress, particularly among affluent children and adolescents.(65-67) This is also called the over-scheduling hypothesis.(65-67) Possibly, there is bias in published research which could affect the appropriateness and interpretation of our findings.

This umbrella review identified a small positive impact of organized sport activities on mental health. Although making inferences based on the included systematic reviews is difficult due to their low quality of reporting on possible bias and different mental health outcomes, the findings are consistent over the systematic reviews included. Participat-

ing in organized sport activities can be stimulated by local policy. Thus, even though the magnitude of effect sizes is small, the impact may not be small if many children and adolescents will participate in organized sport activities. Approximately 40% of children and adolescents worldwide participate in sport.(68) Preventive policies at the local level could contribute to better mental health by stimulating more children and adolescents to participate in organized sport activities. At municipal level, this can be done by for instance increasing the amount of local sport clubs and gyms. At school level, this can be done by for instance offering additional extracurricular activities.(69) Policies could focus on increasing participation in organized sport activities using for instance social media campaigns or by collaborating with local sport organizations.(70)

Further research is needed to examine whether organized activities, particularly non-sport, contribute to better mental health. Research into the impact of organized non-sport activities on child and adolescent mental health is scarce and results are mixed. Based on the positive youth development theory a positive impact on mental health could be present.(13, 15, 49, 51, 52) Future research may shed light on this possible association. More high-quality primary studies and more methodologically sound systematic reviews on organized non-sport activities may ensure this. Future research should disentangle the impact of participating in organized sport activities from mere physical activity. A focus on mental well-being is also warranted in future studies to determine if organized activities have a possible impact on mental health.(2, 7-12)

## Conclusions

We found that there may be a small positive impact on mental health in children and adolescents participating in organized sport activities. This was not dependent on any specific type of organized sport activity. The observed findings should be interpreted cautiously in respect of the small effect sizes that were found, high heterogeneity of primary studies and possible publication bias. We cannot draw any conclusions about organized non-sport activities based on the small number of studies and the mixed results. Further research is needed to unravel possible mechanisms, possible mediation or confounding by physical activity and possible ways of implementing organized activities as positive preventive measure for child and adolescent mental health. This needs to be elaborated on particularly for organized non-sport activities.

# SUPPLEMENTAL MATERIAL

## Appendix A. Full search strategy per database

**Table A1.** Search per database.

| Database searched | via | Years of coverage | Records |
|---|---|---|---|
| **Embase** | Embase.com | 1971 - Present | 467 |
| **Medline ALL** | Ovid | 1946 - Present | 264 |
| **PsycINFO** | Ovid | 1806 - Present | 137 |
| **Web of Science Core Collection**[a] | Web of Knowledge | 1975 - Present | 267 |
| **CINAHL** | EBSCO | 1982 - Present | 191 |
| **Total** | | | 1326[b] |

[a]Science Citation Index Expanded (1975-present) ; Social Sciences Citation Index (1975-present) ; Arts & Humanities Citation Index (1975-present) ; Conference Proceedings Citation Index- Science (1990-present) ; Conference Proceedings Citation Index- Social Science & Humanities (1990-present) ; Emerging Sources Citation Index (2015-present). [b]One additional record was removed in the stage after deduplication, in total there were 776 duplicates. See also the flow- chart.

### Database 1 - embase.com

('sport'/exp OR 'recreation'/de OR dancing/de OR leisure/de OR 'performing arts'/de OR 'recreational game'/de OR 'singing'/exp OR ('physical activity'/de AND ('social interaction'/de OR 'social participation'/de)) OR (sport* OR basketball OR baseball OR cycling OR football OR hockey OR icehockey OR fieldhockey OR jogging OR rugby OR running OR soccer OR softball OR tennis OR squash OR volleyball OR yoga OR fencing OR horse-riding OR horseback-riding OR wrestling OR judo OR karate OR jiu-jitsu OR taekwondo OR kung-fu OR martial-art* OR badminton OR padel OR water-polo OR waterpolo OR skating OR iceskating OR recreation* OR ((organi* OR participat* OR out-of-school OR outside-of-school OR leisure* OR after-school) NEAR/6 activit*) OR ((music* OR drama OR art OR singing) NEAR/6 (participat* OR activ* OR lesson* OR class))):ab,ti) AND ('mental health'/exp OR 'mental disease'/de OR 'behavior disorder'/de OR 'abnormal behavior'/exp OR 'disruptive behavior'/exp OR 'psychosocial disorder'/exp OR 'attention deficit disorder'/exp OR 'mood disorder'/exp OR 'anxiety disorder'/de OR 'adjustment disorder'/de OR 'emotional disorder'/de OR 'externalizing behavior'/de OR 'internalizing behavior'/de OR 'aggression'/de OR aggressiveness/de OR 'anger'/exp OR 'emotion regulation'/de OR 'anxiety'/de OR 'antisocial behavior'/de OR (((mental* OR psychosocial* OR psychologic*) NEAR/3 (health OR problem* OR well-being OR wellbeing OR disorder* OR disease*)) OR depress* OR ((disrupti* OR problem* OR disorder* OR disturb*) NEAR/3 (behav* OR emotion* OR mood OR adjustment*)) OR (mood NEAR/3 (change* OR swing*)) OR anxiety OR adhd OR (attention* NEAR/3 (deficit* OR disorder*)) OR hyperactiv* OR (peer* NEAR/3 (problem*)) OR ((emotional* OR social*) NEAR/3 function*) OR externali* OR internali* OR aggression* OR ((aggressive* OR antisocial*

OR anti-social*) NEAR/3 behav*) OR anger OR (emotion* NEAR/3 regulation*)):ab,ti) AND (juvenile/de OR child/exp OR adolescent/exp OR adolescence/exp OR 'child behavior'/de OR 'child parent relation'/de OR pediatrics/exp OR childhood/exp OR 'child welfare'/de OR 'child development'/de OR 'child growth'/de OR 'child health'/de OR 'child health care'/exp OR 'child care'/exp OR 'child psychiatry'/de OR 'child psychology'/de OR (adolescen* OR preadolescen* OR infan* OR newborn* OR (new NEXT/1 born*) OR baby OR babies OR neonat* OR child* OR kid OR kids OR toddler* OR teen* OR boy* OR girl* OR minors OR underag* OR (under NEXT/1 (age* OR aging OR ageing)) OR juvenil* OR youth* OR kindergar* OR puber* OR pubescen* OR prepubescen* OR prepubert* OR pediatric* OR paediatric* OR school* OR preschool* OR highschool* OR suckling*):ab,ti,kw) AND ('systematic review'/de OR 'meta analysis'/de OR ((systematic* NEAR/3 review*) OR meta-analy* OR metaanaly*):ab,ti)

**Database 2 - Medline ALL Ovid**

(exp Sports/ OR Recreation/ OR Dancing/ OR Leisure Activities/ OR Games, Recreational/ OR Singing/ OR (Exercise/ AND (Interpersonal Relations/ OR Social Participation/)) OR (sport* OR basketball OR baseball OR cycling OR football OR hockey OR icehockey OR fieldhockey OR jogging OR rugby OR running OR soccer OR softball OR tennis OR squash OR volleyball OR yoga OR fencing OR horse-riding OR horseback-riding OR wrestling OR judo OR karate OR jiu-jitsu OR taekwondo OR kung-fu OR martial-art* OR badminton OR padel OR water-polo OR waterpolo OR skating OR iceskating OR recreation* OR ((organi* OR participat* OR out-of-school OR outside-of-school OR leisure* OR after-school) ADJ6 activit*) OR ((music* OR drama OR art OR singing) ADJ6 (participat* OR activ* OR lesson* OR class))).ab,ti.) AND (exp Mental Health/ OR Mental Disorders/ OR exp Social Behavior Disorders/ OR Problem Behavior/ OR exp "Attention Deficit and Disruptive Behavior Disorders"/ OR exp Mood Disorders/ OR exp Anxiety Disorders/ OR Adjustment Disorders/ OR Psychophysiologic Disorders/ OR Aggression/ OR Anger/ OR Emotional Regulation/ OR Anxiety/ OR Antisocial Personality Disorder/ OR (((mental* OR psychosocial* OR psychologic*) ADJ3 (health OR problem* OR well-being OR wellbeing OR disorder* OR disease*)) OR depress* OR ((disrupti* OR problem* OR disorder* OR disturb*) ADJ3 (behav* OR emotion* OR mood OR adjustment*)) OR (mood ADJ3 (change* OR swing*)) OR anxiety OR adhd OR (attention* ADJ3 (deficit* OR disorder*)) OR hyperactiv* OR (peer* ADJ3 (problem*)) OR ((emotional* OR social*) ADJ3 function*) OR externali* OR internali* OR aggression* OR ((aggressive* OR antisocial* OR anti-social*) ADJ3 behav*) OR anger OR (emotion* ADJ3 regulation*)).ab,ti.) AND (exp Child/ OR exp Infant/ OR exp Adolescent/ OR exp Child Behavior/ OR exp Parent Child Relations/ OR exp Pediatrics/ OR exp Child Welfare/ OR Child Development/ OR exp Child Health Services/ OR exp Child Care/ OR Child Rearing/ OR Child Psychiatry/ OR Child Psychology/ OR (adolescen* OR preadolescen* OR infan* OR newborn* OR (new ADJ born*) OR baby OR babies OR

neonat* OR child* OR kid OR kids OR toddler* OR teen* OR boy* OR girl* OR minors OR underag* OR (under ADJ (age* OR aging OR ageing)) OR juvenil* OR youth* OR kindergar* OR puber* OR pubescen* OR prepubescen* OR prepubert* OR pediatric* OR paediatric* OR school* OR preschool* OR highschool* OR suckling*).ab,ti,kw.) AND (systematic review/ OR Meta-Analysis/ OR ((systematic* ADJ3 review*) OR meta-analy* OR metaanaly*).ab,ti.)

**Database 3- PsycINFO Ovid**

(exp Sports/ OR Recreation/ OR Dance/ OR Leisure Time/ OR Games/ OR Singing/ OR (Exercise/ AND (Interpersonal Relationships/ OR Interpersonal Interaction/ OR Social Interaction/ OR Participation/)) OR (sport* OR basketball OR baseball OR cycling OR football OR hockey OR icehockey OR fieldhockey OR jogging OR rugby OR running OR soccer OR softball OR tennis OR squash OR volleyball OR yoga OR fencing OR horse-riding OR horseback-riding OR wrestling OR judo OR karate OR jiu-jitsu OR taekwondo OR kung-fu OR martial-art* OR badminton OR padel OR water-polo OR waterpolo OR skating OR iceskating OR recreation* OR ((organi* OR participat* OR out-of-school OR outside-of-school OR leisure* OR after-school) ADJ6 activit*) OR ((music* OR drama OR art OR singing) ADJ6 (participat* OR activ* OR lesson* OR class))).ab,ti.) AND (exp Mental Health/ OR Mental Disorders/ OR exp Disruptive Behavior Disorders/ OR Behavior Problems/ OR exp Affective Disorders/ OR exp Anxiety Disorders/ OR Adjustment Disorders/ OR Somatoform Disorders/ OR Aggressive Behavior/ OR Aggressiveness/ OR Anger/ OR Emotional Regulation/ OR Anxiety/ OR Antisocial Personality Disorder/ OR (((mental* OR psychosocial* OR psychologic*) ADJ3 (health OR problem* OR well-being OR wellbeing OR disorder* OR disease*)) OR depress* OR ((disrupti* OR problem* OR disorder* OR disturb*) ADJ3 (behav* OR emotion* OR mood OR adjustment*)) OR (mood ADJ3 (change* OR swing*)) OR anxiety OR adhd OR (attention* ADJ3 (deficit* OR disorder*)) OR hyperactiv* OR (peer* ADJ3 (problem*)) OR ((emotional* OR social*) ADJ3 function*) OR externali* OR internali* OR aggression* OR ((aggressive* OR antisocial* OR anti-social*) ADJ3 behav*) OR anger OR (emotion* ADJ3 regulation*)).ab,ti.) AND (exp Child Behavior/ OR exp Parent Child Relations/ OR exp Pediatrics/ OR exp Child Welfare OR exp Child Care/ OR Child Psychiatry/ OR Child Psychology/ OR (adolescen* OR preadolescen* OR infan* OR newborn* OR (new ADJ born*) OR baby OR babies OR neonat* OR child* OR kid OR kids OR toddler* OR teen* OR boy* OR girl* OR minors OR underag* OR (under ADJ (age* OR aging OR ageing)) OR juvenil* OR youth* OR kindergar* OR puber* OR pubescen* OR prepubescen* OR prepubert* OR pediatric* OR paediatric* OR school* OR preschool* OR highschool* OR suckling*).ab,ti. Or 100.ag. OR 200.ag.) AND (systematic review/ OR Meta Analysis/ OR ((systematic* ADJ3 review*) OR meta-analy* OR metaanaly*).ab,ti.)

**Database 4 - Web of Science Core Collection**

(TI=(sport* OR basketball OR baseball OR cycling OR football OR hockey OR icehockey OR fieldhockey OR jogging OR rugby OR running OR soccer OR softball OR tennis OR squash OR volleyball OR yoga OR fencing OR horse-riding OR horseback-riding OR wrestling OR judo OR karate OR jiu-jitsu OR taekwondo OR kung-fu OR martial-art* OR badminton OR padel OR water-polo OR waterpolo OR skating OR iceskating OR recreation* OR ((organi* OR participat* OR out-of-school OR outside-of-school OR leisure* OR after-school) NEAR/5 activit*) OR ((music* OR drama OR art OR singing) NEAR/5 (participat* OR activ* OR lesson* OR class))) OR AB=(sport* OR basketball OR baseball OR cycling OR football OR hockey OR icehockey OR fieldhockey OR jogging OR rugby OR running OR soccer OR softball OR tennis OR squash OR volleyball OR yoga OR fencing OR horse-riding OR horseback-riding OR wrestling OR judo OR karate OR jiu-jitsu OR taekwondo OR kung-fu OR martial-art* OR badminton OR padel OR water-polo OR waterpolo OR skating OR iceskating OR recreation* OR ((organi* OR participat* OR out-of-school OR outside-of-school OR leisure* OR after-school) NEAR/5 activit*) OR ((music* OR drama OR art OR singing) NEAR/5 (participat* OR activ* OR lesson* OR class)))) AND TS=((((mental* OR psychosocial* OR psychologic*) NEAR/2 (health OR problem* OR well-being OR wellbeing OR disorder* OR disease*)) OR depress* OR ((disrupti* OR problem* OR disorder* OR disturb*) NEAR/2 (behav* OR emotion* OR mood OR adjustment*)) OR (mood NEAR/2 (change* OR swing*)) OR anxiety OR adhd OR (attention* NEAR/2 (deficit* OR disorder*)) OR hyperactiv* OR (peer* NEAR/2 (problem*)) OR ((emotional* OR social*) NEAR/2 function*) OR externali* OR internali* OR aggression* OR ((aggressive* OR antisocial* OR anti-social*) NEAR/2 behav*) OR anger OR (emotion* NEAR/2 regulation*))) AND TS=((adolescen* OR preadolescen* OR infan* OR newborn* OR (new NEAR/1 born*) OR baby OR babies OR neonat* OR child* OR kid OR kids OR toddler* OR teen* OR boy* OR girl* OR minors OR underag* OR (under NEAR/1 (age* OR aging OR ageing)) OR juvenil* OR youth* OR kindergar* OR puber* OR pubescen* OR prepubescen* OR prepubert* OR pediatric* OR paediatric* OR school* OR preschool* OR highschool* OR suckling*)) AND TI=(((systematic* NEAR/2 review*) OR meta-analy* OR metaanaly*))

**Database 5- CINAHL EBSCOhost**

(MH Sports+ OR MH Recreation OR MH Dancing OR MH Leisure Activities OR MH Games OR MH Singing OR MH Sporting Events OR (MH Exercise AND (MH Interpersonal Relations OR MH Social Participation)) OR TI (sport* OR basketball OR baseball OR cycling OR football OR hockey OR icehockey OR fieldhockey OR jogging OR rugby OR running OR soccer OR softball OR tennis OR squash OR volleyball OR yoga OR fencing OR horse-riding OR horseback-riding OR wrestling OR judo OR karate OR jiu-jitsu OR taekwondo OR kung-fu OR martial-art* OR badminton OR padel OR water-polo OR waterpolo OR skating OR iceskating OR recreation* OR ((organi* OR participat* OR out-of-school OR outside-of-

school OR leisure* OR after-school) N5 activit*) OR ((music* OR drama OR art OR singing) N5 (participat* OR activ* OR lesson* OR class))) OR AB (sport* OR basketball OR baseball OR cycling OR football OR hockey OR icehockey OR fieldhockey OR jogging OR rugby OR running OR soccer OR softball OR tennis OR squash OR volleyball OR yoga OR fencing OR horse-riding OR horseback-riding OR wrestling OR judo OR karate OR jiu-jitsu OR taekwondo OR kung-fu OR martial-art* OR badminton OR padel OR water-polo OR waterpolo OR skating OR iceskating OR recreation* OR ((organi* OR participat* OR out-of-school OR outside-of-school OR leisure* OR after-school) N5 activit*) OR ((music* OR drama OR art OR singing) N5 (participat* OR activ* OR lesson* OR class)))) AND (MH Mental Health+ OR MH Mental Disorders OR MH Social Behavior Disorders+ OR MH Disruptive Behavior OR MH Attention Deficit Hyperactivity Disorder OR MH Affective Disorders+ OR MH Anxiety Disorders+ OR Adjustment Disorders+ OR MH Psychophysiologic Disorders OR MH Aggression OR MH Anger OR MH Emotional Regulation OR MH Anxiety OR MH Antisocial Personality Disorder OR TI (((mental* OR psychosocial* OR psychologic*) N2 (health OR problem* OR well-being OR wellbeing OR disorder* OR disease*)) OR depress* OR ((disrupti* OR problem* OR disorder* OR disturb*) N2 (behav* OR emotion* OR mood OR Nustment*)) OR (mood N2 (change* OR swing*)) OR anxiety OR adhd OR (attention* N2 (deficit* OR disorder*)) OR hyperactiv* OR (peer* N2 (problem*)) OR ((emotional* OR social*) N2 function*) OR externali* OR internali* OR aggression* OR ((aggressive* OR antisocial* OR anti-social*) N2 behav*) OR anger OR (emotion* N2 regulation*)) OR AB (((mental* OR psychosocial* OR psychologic*) N2 (health OR problem* OR well-being OR wellbeing OR disorder* OR disease*)) OR depress* OR ((disrupti* OR problem* OR disorder* OR disturb*) N2 (behav* OR emotion* OR mood OR Nustment*)) OR (mood N2 (change* OR swing*)) OR anxiety OR adhd OR (attention* N2 (deficit* OR disorder*)) OR hyperactiv* OR (peer* N2 (problem*)) OR ((emotional* OR social*) N2 function*) OR externali* OR internali* OR aggression* OR ((aggressive* OR antisocial* OR anti-social*) N2 behav*) OR anger OR (emotion* N2 regulation*))) AND (MH Child+ OR MH Infant+ OR MH Adolescent+ OR MH Child Behavior+ OR MH Parent Child Relations+ OR MH Pediatrics+ OR MH Child Welfare+ OR Child Development+ OR MH Child Health Services+ OR MH Child Care+ OR MH Child Rearing+ OR MH Child Psychiatry+ OR MH Child Psychology+ OR TI (adolescen* OR preadolescen* OR infan* OR newborn* OR (new N1 born*) OR baby OR babies OR neonat* OR child* OR kid OR kids OR toddler* OR teen* OR boy* OR girl* OR minors OR underag* OR (under N1 (age* OR aging OR ageing)) OR juvenil* OR youth* OR kindergar* OR puber* OR pubescen* OR prepubescen* OR prepubert* OR pediatric* OR paediatric* OR school* OR preschool* OR highschool* OR suckling*) OR AB (adolescen* OR preadolescen* OR infan* OR newborn* OR (new N1 born*) OR baby OR babies OR neonat* OR child* OR kid OR kids OR toddler* OR teen* OR boy* OR girl* OR minors OR underag* OR (under N1 (age* OR aging OR ageing)) OR juvenil* OR youth* OR kindergar* OR puber* OR pubescen* OR prepubescen* OR prepubert* OR pediatric* OR paediatric*

OR school* OR preschool* OR highschool* OR suckling*)) AND (MH systematic review+ OR MH Meta-Analysis+ OR TI ((systematic* N2 review*) OR meta-analy* OR metaanaly*) OR AB ((systematic* N2 review*) OR meta-analy* OR metaanaly*))

## Appendix B. Overlap of primary studies

**Table B1.** Overlap of primary studies included in the systematic reviews.

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | Cairns, 2014 | Collins, 2015 | Eime, 2013 | Evans, 2017 | Panza, 2020 | Zuckerman, 2020 |
| 1 | Adachi PJC, Willoughby T. It's Not How Much You Play, but How Much You Enjoy the Game: The Longitudinal Associations Between Adolescents' Self-Esteem and the Frequency Versus Enjoyment of Involvement in Sports. *Journal of Youth and Adolescence*. 2014/01/01 2014;43(1):137-145. doi:10.1007/s10964-013-9988-3 | | | | X | | |
| 2 | Agans JP, Geldhof GJ. Trajectories of Participation in Athletics and Positive Youth Development: The Influence of Sport Type. doi: 10.1080/10888691.2012.697792. *Applied Developmental Science*. 2012/07/01 2012;16(3):151-165. doi: 10.1080/10888691.2012.697792 | | | | X | X | |
| 3 | Ashdown-Franks G, Sabiston CM, Solomon-Krakus S, O'Loughlin JL. Sport participation in high school and anxiety symptoms in young adulthood. *Mental Health and Physical Activity*. 2017/03/01/ 2017;12:19-24. doi:https://doi.org/10.1016/j.mhpa.2016.12.001 | | | | | X | |
| 4 | Babiss LA, Gangwisch JE. Sports participation as a protective factor against depression and suicidal ideation in adolescents as mediated by self-esteem and social support. *J Dev Behav Pediatr*. Oct 2009;30(5):376-84. | | | | | X | |
| 5 | Badura P, Geckova AM, Sigmundova D, van Dijk JP, Reijneveld SA. When children play, they feel better: organized activity participation and health in adolescents. *BMC Public Health*. 2015/10/24 2015;15(1):1090. doi:10.1186/s12889-015-2427-5 | | | | | | X |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **6** | Baldursdottir B, Valdimarsdottir HB, Krettek A, Gylfason HF, Sigfusdottir ID. Age-related differences in physical activity and depressive symptoms among 10–19-year-old adolescents: A population based study. *Psychology of Sport and Exercise*. 2017/01/01/ 2017;28:91-99. doi:https://doi.org/10.1016/j.psychsport.2016.10.007 | | | | | X | |
| **7** | Barber BL, Eccles JS, Stone MR. Whatever Happened to the Jock, the Brain, and the Princess?: Young Adult Pathways Linked to Adolescent Activity Involvement and Social Identity. doi: 10.1177/0743558401165002. *Journal of Adolescent Research*. 2001/09/01 2001;16(5):429-455. doi:10.1177/0743558401165002 | X | | X | | | |
| **8** | Bartko WT, Eccles JS. Adolescent Participation in Structured and Unstructured Activities: A Person-Oriented Analysis. *Journal of Youth and Adolescence*. 2003/08/01 2003;32(4):233-241. doi:10.1023/a:1023056425648 | | | X | | | |
| **9** | Begg DJ, Langley JD, Moffitt T, Marshall SW. Sport and delinquency: an examination of the deterrence hypothesis in a longitudinal study. *Br J Sports Med*. 1996;30(4):335-341. doi:10.1136/bjsm.30.4.335 | | | | | | X |
| **10** | Boone EM, Leadbeater BJ. Game On: Diminishing Risks for Depressive Symptoms in Early Adolescence Through Positive Involvement in Team Sports. https://doi.org/10.1111/j.1532-7795.2006.00122.x. *Journal of Research on Adolescence*. 2006/03/01 2006;16(1):79-90. doi:https://doi.org/10.1111/j.1532-7795.2006.00122.x | | | X | | X | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **11** | Bowker A. The relationship between sports participation and self-esteem during early adolescence. doi:10.1037/cjbs2006009. *Canadian Journal of Behavioural Science / Revue canadienne des sciences du comportement*. 2006;38(3):214-229. doi:10.1037/cjbs2006009 | | | X | | | |
| **12** | Brettschneider W-d. Effects of sport club activities on adolescent development in Germany. doi: 10.1080/17461390100071201. *European Journal of Sport Science*. 2001/06/01 2001;1(2):1-11. doi:10.1080/17461390100071201 | | | X | | | |
| **13** | Brière FN, Yale-Soulière G, Gonzalez-Sicilia D, et al. Prospective associations between sport participation and psychological adjustment in adolescents. *Journal of Epidemiology and Community Health*. 2018;72(7):575. doi:10.1136/jech-2017-209656 | | | | | X | X |
| **14** | Bruner MW, Hall J, Côté J. Influence of sport type and interdependence on the developmental experiences of youth male athletes. doi: 10.1080/17461391.2010.499969. *European Journal of Sport Science*. 2011/03/01 2011;11(2):131-142. doi: 10.1080/17461391.2010.499969 | | | | X | | |
| **15** | Brunet J, Sabiston CM, Chaiton M, et al. The association between past and current physical activity and depressive symptoms in young adults: a 10-year prospective study. *Ann Epidemiol*. Jan 2013;23(1):25-30. | X | | | | X | |
| **16** | Calmeiro L, Stoll S, Davis PJ. Moral Reasoning in Sport: Validation of the Portuguese Version of the RSBH Value-Judgement Inventory in Adolescents. *Sport Science Review*. 2015;24:285 - 304. | | | | X | | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | Cairns, 2014 | Collins, 2015 | Eime, 2013 | Evans, 2017 | Panza, 2020 | Zuckerman, 2020 |
| **17** | Chen SY, Lu L. After-school time use in Taiwan: effects on educational achievement and well-being. *Adolescence*. Winter 2009;44(176):891-909. | X | | | | | |
| **18** | Choi WS, Patten CA, Gillin JC, Kaplan RM, Pierce JP. Cigarette smoking predicts development of depressive symptoms among U.S. adolescents. *Ann Behav Med*. Winter 1997;19(1):42-50. | X | | | | | |
| **19** | Clifford T, Blyth C. A pilot study comparing the prevalence of orthorexia nervosa in regular students and those in University sports teams. *Eat Weight Disord*. Jun 2019;24(3):473-480. | | | | | | X |
| **20** | Darling N. Participation in Extracurricular Activities and Adolescent Adjustment: Cross-Sectional and Longitudinal Findings. *Journal of Youth and Adolescence*. 2005/10/01 2005;34(5):493-505. doi:10.1007/s10964-005-7266-8 | X | | | | | |
| **21** | De Meester A, Aelterman N, Cardon G, De Bourdeaudhuij I, Haerens L. Extracurricular school-based sports as a motivating vehicle for sports participation in youth: a cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity*. 2014/04/07 2014;11(1):48. doi:10.1186/1479-5868-11-48 | | | | X | | |
| **22** | Denault A-S, Poulin F, Pedersen S. Intensity of Participation in Organized Youth Activities During the High School Years: Longitudinal Associations With Adjustment. doi: 10.1080/10888690902801459. *Applied Developmental Science*. 2009/04/16 2009;13(2):74-87. doi:10.1080/10888690902801459 | X | | | | X | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **23** | Dimech AS, Seiler R. Extra-curricular sport participation: A potential buffer against social anxiety symptoms in primary school childre" *Psychology of Sport and Exercise*. 2011;12:347-354. | | | X | X | | |
| **24** | Dishman RK, Hales DP, Pfeiffer KA, et al. Physical self-concept and self-esteem mediate cross-sectional relations of physical activity and sport participation with depression symptoms among adolescent girls. *Health Psychol*. May 2006;25(3):396-407. | | | | | X | |
| **25** | Dolenc P. Anxiety, Self-Esteem and Coping with Stress in Secondary School Students in Relation to Involvement in Organized Sports. *Zdr Varst*. Sep 2015;54(3):222-9. | | | | | X | |
| **26** | Donaldson SJ, Ronan KR. The effects of sports participation on young adolescents' emotional well-being. *Adolescence*. Summer 2006;41(162):369-89. | | | X | | | |
| **27** | Donkers JL, Martin LJ, Evans MB. Psychological collectivism in youth athletes on individual sport teams. *International Journal of Sport and Exercise Psychology*. 2018;16(3):285-299. | | | | X | | |
| **28** | Doré I, O'Loughlin JL, Schnitzer ME, Datta GD, Fournier L. The longitudinal association between the context of physical activity and mental health in early adulthood. *Mental Health and Physical Activity*. 2018/03/01/ 2018;14:121-130. doi:https://doi.org/10.1016/j.mhpa.2018.04.001 | | | | | X | |
| **29** | Dugas E, Low NC, Rodriguez D, et al. Early predictors of suicidal ideation in young adults. *Can J Psychiatry*. Jul 2012;57(7):429-36. | | | | | | X |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **30** | Duncan SC, Strycker LA, Chaumeton NR. Sports Participation and Positive Correlates in African American, Latino, and White Girls. doi: 10.1080/10888691.2015.1020156. *Applied Developmental Science*. 2015/10/02 2015;19(4):206-216. doi: 10.1080/10888691.2015.1020156 | | | | | X | |
| **31** | Easterlin MC, Chung PJ, Leng M, Dudovitz R. Association of Team Sports Participation With Long-term Mental Health Outcomes Among Individuals Exposed to Adverse Childhood Experiences. *JAMA Pediatrics*. 2019;173(7):681-688. doi:10.1001/ jamapediatrics.2019.1212 | | | | | X | X |
| **32** | Erkut S, Tracy AJ. Predicting Adolescent Self-Esteem From Participation in School Sports Among Latino Subgroups. *Hisp J Behav Sci*. 2002;24(4):409-429. doi:10.1177/0739986302238212 | | | X | | | |
| **33** | Faigenbaum A, Zaichowsky LD, Westcott WL, et al. Psychological effects of strength training on children. Article. *Journal of Sport Behavior*. 1997/06// 1997;20(2):164+. | | X | | | | |
| **34** | Fatiregun AA, Kumapayi TE. Prevalence and correlates of depressive symptoms among in-school adolescents in a rural district in southwest Nigeria. *Journal of Adolescence*. 2014/02/01/ 2014;37(2):197-203. doi:https://doi.org/10.1016/j. adolescence.2013.12.003 | | | | | X | |
| **35** | Feldman AF. *Links between school-based extracurricular activity participation and adolescent development*. 2003. | X | | | | | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **36** | Ferron C, Narring F, Cauderay M, Michaud PA. Sport activity in adolescence: associations with health perceptions and experimental behaviours. *Health Educ Res*. Apr 1999;14(2):225-33. | | | X | | | |
| **37** | Findlay L, Coplan R. Come out and play: Shyness in childhood and the benefits of organized sports participation. *Canadian Journal of Behavioural Science*. 2008;40:153-161. | | | X | | | |
| **38** | Forsman H, Blomqvist M, Davids K, Konttinen N, Liukkonen J. The role of sport-specific play and practice during childhood in the development of adolescent Finnish team sport athletes. doi: 10.1177/1747954115624816. *International Journal of Sports Science & Coaching*. 2016/02/01 2016;11(1):69-77. doi:10.1177/1747954115624816 | | | | X | | |
| **39** | Fredricks JA, Eccles JS. Is extracurricular participation associated with beneficial outcomes? Concurrent and longitudinal relations. *Dev Psychol*. Jul 2006;42(4):698-713. | X | | | | X | |
| **40** | Fredricks JA, Eccles JS. Participation in Extracurricular Activities in the Middle School Years: Are There Developmental Benefits for African American and European American Youth? *Journal of Youth and Adolescence*. 2008/10/01 2008;37(9):1029-1043. doi:10.1007/s10964-008-9309-4 | X | | | | | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **41** | Fredricks JA, Eccles JS. Breadth of Extracurricular Participation and Adolescent Adjustment Among African-American and European-American Youth. https://doi.org/10.1111/j.1532-7795.2009.00627.x. *Journal of Research on Adolescence*. 2010/06/01 2010;20(2):307-333. doi:https://doi.org/10.1111/j.1532-7795.2009.00627.x | X | | | | | |
| **42** | Goldfield GS, Kenny GP, Alberga AS, et al. Effects of aerobic training, resistance training, or both on psychological health in adolescents with obesity: The HEARTY randomized controlled trial. *J Consult Clin Psychol*. Dec 2015;83(6):1123-35. | | X | | | | |
| **43** | Gomez-Baya D, Mendoza R, Matos MGd, Tomico A. Sport participation, body satisfaction and depressive symptoms in adolescence: a moderated-mediation analysis of gender differences. doi: 10.1080/17405629.2017.1364988. *European Journal of Developmental Psychology*. 2019/03/04 2019;16(2):183-197. doi:10.1080/17405629.2017.1364988 | | | | | X | |
| **44** | Gore S, Farrell F, Gordon J. Sports Involvement as Protection against Depressed Mood. https://doi.org/10.1111/1532-7795.00006. *Journal of Research on Adolescence*. 2001/03/01 2001;11(1):119-130. doi:https://doi.org/10.1111/1532-7795.00006 | | | X | X | X | |
| **45** | Gucciardi DF. The relationship between developmental experiences and mental toughness in adolescent cricketers. *J Sport Exerc Psychol*. Jun 2011;33(3):370-93. | | | | X | | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **46** | Guddal MH, Stensland S, Småstuen MC, Johnsen MB, Zwart JA, Storheim K. Physical activity and sport participation among adolescents: associations with mental health in different age groups. Results from the Young-HUNT study: a cross-sectional survey. *BMJ Open*. Sep 4 2019;9(9):e028555. | | | | | | X |
| **47** | Hammond T, Gialloreto C, Kubas H, Hap Davis Ht. The prevalence of failure-based depression among elite athletes. *Clin J Sport Med*. Jul 2013;23(4):273-7. | | | | | | X |
| **48** | Hansen DM, Larson RW, Dworkin JB. What Adolescents Learn in Organized Youth Activities: A Survey of Self-Reported Developmental Experiences. https://doi.org/10.1111/1532-7795.1301006. *Journal of Research on Adolescence*. 2003/03/01 2003;13(1):25-55. doi:https://doi.org/10.1111/1532-7795.1301006 | | | X | | | |
| **49** | Harrison PA, Narayan G. Differences in behavior, psychological factors, and environmental factors associated with participation in school sports and other activities in adolescence. *J Sch Health*. Mar 2003;73(3):113-20. | | | X | | | X |
| **50** | He JP, Paksarian D, Merikangas KR. Physical Activity and Mental Disorder Among Adolescents in the United States. *J Adolesc Health*. Nov 2018;63(5):628-635. | | | | | X | |
| **51** | Hendry DT, Crocker PR, Hodges NJ. Practice and play as determinants of self-determined motivation in youth soccer players. *J Sports Sci*. 2014;32(11):1091-9. | | | | X | | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **52** | Holloway JB, Beuter A, Duda JL. Self-Efficacy and Training for Strength in Adolescent Girls1. https://doi.org/10.1111/j.1559-1816.1988.tb00046.x. *Journal of Applied Social Psychology*. 1988/06/01 1988;18(8):699-719. doi:https://doi.org/10.1111/j.1559-1816.1988.tb00046.x | | X | | | | |
| **53** | Holt NL, Kingsley BC, Tink LN, Scherer J. Benefits and challenges associated with sport participation by children and parents from low-income families. *Psychology of Sport and Exercise*. 2011/09/01/ 2011;12(5):490-499. doi:https://doi.org/10.1016/j.psychsport.2011.05.007 | | | X | | | |
| **54** | Howie LD, Lukacs SL, Pastor PN, Reuben CA, Mendola P. Participation in activities outside of school hours in relation to problem behavior and social skills in middle childhood. *J Sch Health*. Mar 2010;80(3):119-25. | | | X | | | |
| **55** | Howie, 2016$_a$ | | | | | X | |
| **56** | Hume C, Timperio A, Veitch J, Salmon J, Crawford D, Ball K. Physical activity, sedentary behaviour and depressive symptoms among adolescents. *Journal of Science and Medicine in Sport*. 2010/01/01/ 2010;12:e142. doi:https://doi.org/10.1016/j.jsams.2009.10.297 | X | | | | X | |
| **57** | Imtiaz F, Hancock DJ, Côté J. Examining Young Recreational Male Soccer Players' Experience in Adult- and Peer-Led Structures. *Res Q Exerc Sport*. Sep 2016;87(3):295-304. | | | | X | | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **58** | Jewett R, Sabiston CM, Brunet J, O'Loughlin EK, Scarapicchia T, O'Loughlin J. School Sport Participation During Adolescence and Mental Health in Early Adulthood. *Journal of Adolescent Health*. 2014/11/01/ 2014;55(5):640-644. doi:https://doi.org/10.1016/j.jadohealth.2014.04.018 | | | | | X | |
| **59** | Karr TM, Davidson D, Bryant FB, Balague G, Bohnert AM. Sport type and interpersonal and intrapersonal predictors of body dissatisfaction in high school female sport participants. *Body image*. 2013;10(2):210-219. | | | | X | | |
| **60** | Kleppang AL, Hartz I, Thurston M, Hagquist C. The association between physical activity and symptoms of depression in different contexts – a cross-sectional study of Norwegian adolescents. *BMC Public Health*. 2018/12/12 2018;18(1):1368. doi:10.1186/s12889-018-6257-0 | | | | | | X |
| **61** | Koh KT, Wang CKJ. Gender and type of sport differences on perceived coaching behaviours, achievement goal orientations and life aspirations of youth Olympic games Singaporean athletes. doi: 10.1080/1612197X.2014.932820. *International Journal of Sport and Exercise Psychology*. 2015/04/03 2015;13(2):91-103. doi:10.1080/1612197x.2014.932820 | | | | X | | |
| **62** | Kokotailo PK, Henry BC, Koscik RE, Fleming MF, Landry GL. Substance use and other health risk behaviors in collegiate athletes. *Clin J Sport Med*. Jul 1996;6(3):183-9. | | | | | | X |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **63** | Kremer P, Elshaug C, Leslie E, Toumbourou JW, Patton GC, Williams J. Physical activity, leisure-time screen use and depression among children and young adolescents. *J Sci Med Sport*. Mar 2014;17(2):183-7. | | | | | X | |
| **64** | Lee M, Whitehead J, Balchin N. The Measurement of Values in Youth Sport: Development of the Youth Sport Values Questionnaire. *Journal of Sport & Exercise Psychology*. 2000;22:307-326. | | | | X | | |
| **65** | Lee MJ, Whitehead J, Ntoumanis N. Development of the Attitudes to Moral Decision-making in Youth Sport Questionnaire (AMDYSQ). *Psychology of Sport and Exercise*. 2007/05/01/ 2007;8(3):369-392. doi:https://doi.org/10.1016/j.psychsport.2006.12.002 | | | | X | | |
| **66** | Leapetswe M. Goal Orientations, Sport Ability, Perceived Parental Influences and Youths` Enjoyment of Sport and Physical Activity in Botswana. *International Journal of Applied sports sciences (IJASS)*. 2006;18 (2 ):89. | | | | X | | |
| **67** | Linver MR, Roth JL, Brooks-Gunn J. Patterns of adolescents' participation in organized activities: are sports best when combined with other activities? *Dev Psychol*. Mar 2009;45(2):354-67. | | | X | | | |
| **68** | Lubans D, Aguiar EJ, Callister R. The effects of free weights and elastic tubing resistance training on physical self-perception in adolescents. *Psychology of Sport and Exercise*. 2010;11:497-504. | | X | | | | |
| **69** | Marsh H. The Effects of Participation in Sport during the Last Two Years of High School. *Sociology of Sport Journal*. 1993;10:18-43. | | | X | | | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **70** | Martin LJ, Balderson D, Hawkins M, Wilson K, Bruner MW. The influence of social identity on self-worth, commitment, and effort in school-based youth sport. *J Sports Sci*. Feb 2018;36(3):326-332. | | | | | | X |
| **71** | Martin LJ, Carron AV, Eys MA, Loughead T. Validation of the Child Sport Cohesion Questionnaire. doi: 10.1080/1091367X.2013.761023. *Measurement in Physical Education and Exercise Science*. 2013/04/01 2013;17(2):105-119. doi:10.1080/1091367x.2013.761023 | | | | X | | |
| **72** | McClure AC, Tanski SE, Kingsbury J, Gerrard M, Sargent JD. Characteristics associated with low self-esteem among US adolescents. *Acad Pediatr*. Jul-Aug 2010;10(4):238-44 e2. | | | | | | X |
| **73** | McFadden T, Bean C, Fortier M, Post C. Investigating the influence of youth hockey specialization on psychological needs (dis)satisfaction, mental health, and mental illness. doi: 10.1080/23311908.2016.1157975. *Cogent Psychology*. 2016/12/31 2016;3(1):1157975. doi:10.1080/23311908.2016.1157975 | | | | X | | |
| **74** | McGale N, McArdle S, Gaffney P. Exploring the effectiveness of an integrated exercise/CBT intervention for young men's mental health. *Br J Health Psychol*. Sep 2011;16(3):457-71. | | | | | | X |
| **75** | McMahon EM, Corcoran P, O'Regan G, et al. Physical activity in European adolescents and associations with anxiety, depression and well-being. *Eur Child Adolesc Psychiatry*. Jan 2017;26(1):111-122. | | | | | X | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **76** | Merglen A, Flatz A, Bélanger RE, Michaud PA, Suris JC. Weekly sport practice and adolescent well-being. *Arch Dis Child*. Mar 2014;99(3):208-10. | | | | X | | |
| **77** | Michaud PA, Jeannin A, Suris JC. Correlates of extracurricular sport participation among Swiss adolescents. *Eur J Pediatr*. Aug 2006;165(8):546-55. | | | X | | | |
| **78** | Moeijes J, van Busschbach JT, Bosscher RJ, Twisk JWR. Sports participation and psychosocial health: a longitudinal observational study in children. *BMC Public Health*. 2018/06/07 2018;18(1):702. doi:10.1186/s12889-018-5624-1 | | | | | | X |
| **79** | Moeijes J, van Busschbach JT, Wieringa TH, Kone J, Bosscher RJ, Twisk JWR. Sports participation and health-related quality of life in children: results of a cross-sectional study. *Health and Quality of Life Outcomes*. 2019/04/15 2019;17(1):64. doi:10.1186/s12955-019-1124-y | | | | | | X |
| **80** | Mullane SL, Bocchicchio VB, Crespo NC. Feasibility and Parental Acceptability of an 8-Week, Slow-Speed, High-Intensity, Community-Based Resistance Training Program for Preadolescent Children. *Fam Community Health*. Jul/Sep 2017;40(3):183-191. | | X | | | | |
| **81** | Newcombe PA, Boyle GJ. High school students' sport personalities: Variations across participation level, gender, type of sport, and success. *International Journal of Sport Psychology*. 1995;26:277-294. | | | | X | | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **82** | Nixdorf I, Frank R, Beckmann J. Comparison of Athletes' Proneness to Depressive Symptoms in Individual and Team Sports: Research on Psychological Mediators in Junior Elite Athletes. Original Research. *Frontiers in Psychology*. 2016-June-17 2016;7(893)doi:10.3389/fpsyg.2016.00893 | | | | X | | |
| **83** | Ogawa S, Kitagawa Y, Fukushima M, et al. Interactive effect of sleep duration and physical activity on anxiety/depression in adolescents. *Psychiatry Res*. Mar 2019;273:456-460. | | | | | X | |
| **84** | Pastor Y, Balaguer I, Pons D, García-Merita M. Testing direct and indirect effects of sports participation on perceived health in Spanish adolescents between 15 and 18 years of age. *J Adolesc*. Dec 2003;26(6):717-30. | | | | | X | |
| **85** | Pate RR, Trost SG, Levin S, Dowda M. Sports participation and health-related behaviors among US youth. *Arch Pediatr Adolesc Med*. Sep 2000;154(9):904-11. | | | | | | X |
| **86** | Pedersen S, Seidman E. Team Sports Achievement and Self-Esteem Development Among Urban Adolescent Girls. doi: 10.1111/j.1471-6402.2004.00158.x. *Psychology of Women Quarterly*. 2004/12/01 2004;28(4):412-422. doi:10.1111/j.1471-6402.2004.00158.x | | | X | | | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **87** | Perron A, Brendgen M, Vitaro F, Côté SM, Tremblay RE, Boivin M. Moderating effects of team sports participation on the link between peer victimization and mental health problems. *Mental Health and Physical Activity*. 2012/12/01/ 2012;5(2):107-115. doi:https://doi.org/10.1016/j.mhpa.2012.08.006 | | | | X | | |
| **88** | Pluhar E, McCracken C, Griffith KL, Christino MA, Sugimoto D, Meehan WP, 3rd. Team Sport Athletes May Be Less Likely To Suffer Anxiety or Depression than Individual Sport Athletes. *J Sports Sci Med*. Sep 2019;18(3):490-496. | | | | | | X |
| **89** | Pyle RP, McQuivey RW, Brassington GS, Steiner H. High school student athletes: associations between intensity of participation and health factors. *Clin Pediatr (Phila)*. Oct 2003;42(8):697-701. | | | X | | | |
| **90** | Rascle O, Coulomb G, Pfister R. Aggression and goal orientations in handball: influence of institutional sport context. *Percept Mot Skills*. Jun 1998;86(3 Pt 2):1347-60. | | | | X | | |
| **91** | Rodriguez D, Moss HB, Audrain-McGovern J. Developmental heterogeneity in adolescent depressive symptoms: associations with smoking behavior. *Psychosom Med*. Mar-Apr 2005;67(2):200-10. | X | | | | | |
| **92** | Rodriguez D, Moss HB, Audrain-McGovern J. Developmental heterogeneity in adolescent depressive symptoms: associations with smoking behavior. *Psychosom Med*. Mar-Apr 2005;67(2):200-10. | | | | | | X |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **93** | Sabiston CM, Jewett R, Ashdown-Franks G, et al. Number of Years of Team and Individual Sport Participation During Adolescence and Depressive Symptoms in Early Adulthood. *J Sport Exerc Psychol*. Feb 2016;38(1):105-10. | | | | | X | |
| **94** | Sanders CE, Field TM, Diego M, Kaplan M. Moderate involvement in sports is related to lower depression levels among adolescents. *Adolescence*. Winter 2000;35(140):793-7. | | | X | X | X | |
| **95** | Schranz N, Tomkinson G, Parletta N, Petkov J, Olds T. Can resistance training change the strength, body composition and self-concept of overweight and obese adolescent males? A randomised controlled trial. *Br J Sports Med*. Oct 2014;48(20):1482-8. | | X | | | | |
| **96** | Seidel RW, Reppucci ND. Organized youth sports and the psychological development of nine-year-old males. *Journal of Child and Family Studies*. 1993/09/01 1993;2(3):229-248. doi:10.1007/bf01321333 | | | | X | | |
| **97** | Shields DL, LaVoi NM, Bredemeier BL, Power FC. Predictors of poor sportspersonship in youth sports: personal attitudes and social influences. *J Sport Exerc Psychol*. Dec 2007;29(6):747-62. | | | | X | | |
| **98** | Slutzky CB, Simpkins SD. The link between children's sport participation and self-esteem: Exploring the mediating role of sport self-concept. *Psychology of Sport and Exercise*. 2009/05/01/ 2009;10(3):381-389. doi:https://doi.org/10.1016/j.psychsport.2008.09.006 | | | | X | | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **99** | Snyder AR, Martinez JC, Bay RC, Parsons JT, Sauers EL, Valovich McLeod TC. Health-related quality of life differs between adolescent athletes and adolescent nonathletes. *J Sport Rehabil*. Aug 2010;19(3):237-48. | | | X | | | |
| **100** | Steiner H, McQuivey RW, Pavelski R, Pitts T, Kraemer H. Adolescents and Sports: Risk or Benefit? doi: 10.1177/000992280003900304. *Clinical Pediatrics*. 2000/03/01 2000;39(3):161-166. doi:10.1177/000992280003900304 | | | X | | | |
| **101** | Steptoe A, Butler N. Sports participation and emotional wellbeing in adolescents. *Lancet*. Jun 29 1996;347(9018):1789-92. | | | X | | | X |
| **102** | Stiffman AR, Chueh H-j, Earls F. Predictive modeling of change in depressive disorder and counts of depressive symptoms in urban youths. doi:10.1207/s15327795jra0204_1. *Journal of Research on Adolescence*. 1992;2(4):295-316. doi:10.1207/s15327795jra0204_1 | X | | | | | |
| **103** | Strachan L, Côté J, Deakin J. "Specializers" versus "samplers" in youth sport: comparing experiences and outcomes. *The sport psychologist*. 2009;23(1):77-92. | | | | X | | |
| **104** | Taliaferro LA, Eisenberg ME, Johnson KE, Nelson TF, Neumark-Sztainer D. Sport participation during adolescence and suicide ideation and attempts. *Int J Adolesc Med Health*. 2011;23(1):3-10. | | | X | | | |
| **105** | Taliaferro LA, Rienzo BA, Miller MD, Pigg RM, Jr., Dodd VJ. High school youth and suicide risk: exploring protection afforded through physical activity and sport participation. *J Sch Health*. Oct 2008;78(10):545-53. | | | X | X | | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **106** | Thomas GL, Wilson MR. Playing by the Rules: A Developmentally Appropriate Introduction to Rugby Union. doi: 10.1260/1747-9541.10.2-3.413. *International Journal of Sports Science & Coaching*. 2015/06/01 2015;10(2-3):413-423. doi:10.1260/1747-9541.10.2-3.413 | | | | X | | |
| **107** | Valois RF, Umstattd MR, Zullig KJ, Paxton RJ. Physical Activity Behaviors and Emotional Self-Efficacy: Is There a Relationship for Adolescents? https://doi.org/10.1111/j.1746-1561.2008.00309.x. *Journal of School Health*. 2008/06/01 2008;78(6):321-327. doi:https://doi.org/10.1111/j.1746-1561.2008.00309.x | | | X | | | X |
| **108** | Valois RF, Zullig KJ, Huebner ES, Drane JW. Physical activity behaviors and perceived life satisfaction among public high school adolescents. *J Sch Health*. Feb 2004;74(2):59-65. | | | X | | | |
| **109** | Van Voorhees BW, Paunesku D, Fogel J, Bell CC. Differences in vulnerability factors for depressive episodes in African American and European American adolescents. *Journal of the National Medical Association*. 2009;101(12):1255-1267. | X | | | | | |
| **110** | Velez A, Golem DL, Arent SM. The impact of a 12-week resistance training program on strength, body composition, and self-concept of Hispanic adolescents. *J Strength Cond Res*. Apr 2010;24(4):1065-73. | | X | | | | |
| **111** | Vella SA, Cliff DP, Magee CA, Okely AD. Sports participation and parent-reported health-related quality of life in children: longitudinal associations. *J Pediatr*. Jun 2014;164(6):1469-74. | | | | X | | |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **112** | Vella SA, Swann C, Allen MS, Schweickle MJ, Magee CA. Bidirectional Associations between Sport Involvement and Mental Health in Adolescence. *Med Sci Sports Exerc*. Apr 2017;49(4):687-694. | | | | | | X |
| **113** | Vink K, Raudsepp L, Kais K. Intrinsic motivation and individual deliberate practice are reciprocally related: Evidence from a longitudinal study of adolescent team sport athletes. *Psychology of sport and Exercise*. 2015;16:1-6. | | | | X | | |
| **114** | Wagnsson S, Lindwall M, Gustafsson H. Participation in organized sport and self-esteem across adolescence: the mediating role of perceived sport competence. *Journal of sport and exercise psychology*. 2014;36(6):584-594. | | | | X | | |
| **115** | Wang MT, Chow A, Amemiya J. Who Wants to Play? Sport Motivation Trajectories, Sport Participation, and the Development of Depressive Symptoms. *J Youth Adolesc*. Sep 2017;46(9):1982-1998. | | | | | X | |
| **116** | Wiersma LD, Fifer AM. "The Schedule Has Been Tough But We Think It's Worth It": The Joys, Challenges, and Recommendations of Youth Sport Parents. doi: 10.1080/00222216.2008.11950150. *Journal of Leisure Research*. 2008/12/01 2008;40(4):505-530. doi: 10.1080/00222216.2008.11950150 | | | X | | | |
| **117** | Yang J, Peek-Asa C, Corlette JD, Cheng G, Foster DT, Albright J. Prevalence of and risk factors associated with symptoms of depression in competitive collegiate student athletes. *Clin J Sport Med*. Nov 2007;17(6):481-7. | | | | | | X |

**Table B1.** Overlap of primary studies included in the systematic reviews. (Continued)

| Number of the primary study | Unique primary study | Unique primary study is included in the systematic review | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Cairns, 2014** | **Collins, 2015** | **Eime, 2013** | **Evans, 2017** | **Panza, 2020** | **Zuckerman, 2020** |
| **118** | Zarrett N, Fay K, Li Y, Carrano J, Phelps E, Lerner RM. More than child's play: Variable- and pattern-centered approaches for examining effects of sports participation on youth development. doi:10.1037/a0014577. *Developmental Psychology*. 2009;45(2):368-382. doi:10.1037/a0014577 | | | X | X | X | |

[a]Panza did not mention this in the reference list but it is included as a primary study in their systematic review.

**Amount of primary studies per review:**

| | |
|---|---|
| Cairns, 2014: | 15 |
| Collins, 2015: | 7 |
| Eime, 2013: | 30 |
| Evans, 2017: | 35 |
| Panza, 2020: | 29 |
| Zuckerman, 2020: | 23 |
| Total: | 139 |

**Calculations by Pieper and colleagues [1]:**

**1- Percentage of primary studies included in multiple reviews**

Out of the 118 unique primary studies, 17 are included in 2 or more of the 6 reviews. This is a percentage of (7/118)*100% = **14.41%** of the unique primary studies.

**2- Corrected covered Area (CCA)**

CCA = (N – r) / ((r*c) – r)

in which N = the number of included publications (including double counting) in evidence synthesis; r = the number of index publications; c = the number of reviews.

CCA = (139-118) / ((118*6) - 118) = **0.0355**

**References:**

1. Pieper D, Antoine SL, Mathes T, Neugebauer EA, Eikermann M. Systematic review finds overlapping reviews were not mentioned in every other overview. J Clin Epidemiol. Apr 2014;67(4):368-75. doi:S0895-4356(13)00481-2 [pii] 10.1016/j.jclinepi.2013.11.007

## Appendix C. Formulas

FORMULA 1 – Odds ratio (OR) to Cohen's d (71)

$$d \approx \frac{\sqrt{3}}{\pi} * L_{OR}$$

*with $L_{OR}$ being the natural logarithm of the odds ratio*

FORMULA 2 – Hedge's $g$ to Cohen's d (36)

$$d \approx \frac{1}{J(df)} * g$$

*with J being the small-sample correction factor*

Or if the sample sizes are large enough:

$$d \approx g$$

FORMULA 3 – Pearson's r to Cohen's $d$ (36)

$$d \approx \frac{2 \cdot r}{\sqrt{1 - r^2}}$$

### References


1. Sánchez-Meca J, Marín-Martínez F, Chacón-Moscoso S. Effect-size indices for dichotomized outcomes in meta-analysis. Psychol Methods. Dec 2003;8(4):448-67.
2. Fusar-Poli P, Radua J. Ten simple rules for conducting umbrella reviews. Evidence Based Mental Health. 2018;21:ebmental-2018. doi:10.1136/ebmental-2018-300014

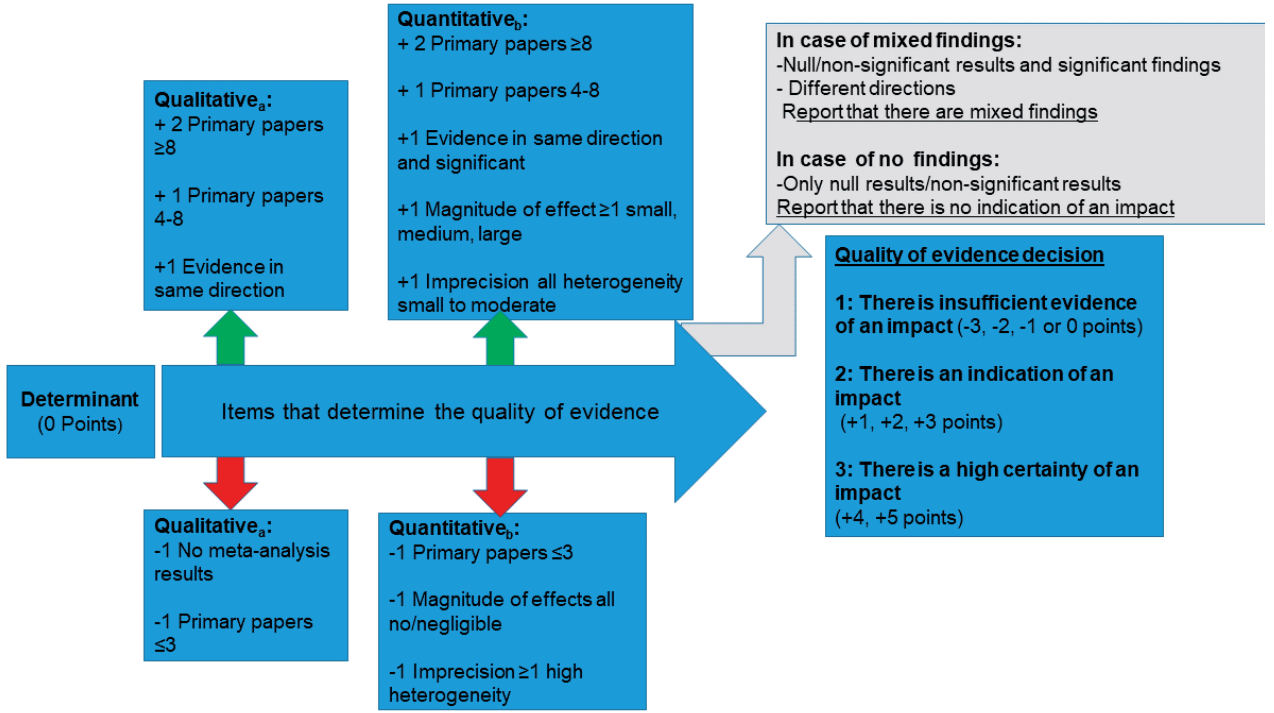


**Figure S1.** Self-developed decision scheme for a quality of evidence assessment for our umbrella review.
$_a$Qualitative indicates that the results from the systematic reviews to this determinant included no meta-analyses and that we synthesized only qualitative results. $_b$Quantitative indicates that the results from the systematic reviews to this determinant included meta-analyses and that we synthesized results from the meta-analyses.

**Table D1.** Self-developed decision scheme and scoring for a quality assessment for our umbrella review

| Items that determine the quality of the systematic review | points |
|---|---|
| ***Results from meta-analysis*** | |
| No | -1 |
| ***Number of primary papers*** | |
| ≤3 primary papers report on this factor | -1 |
| 4-8 primary papers report on this factor | +1 |
| ≥8 primary papers report on this factor | +2 |
| ***Significance and direction of results*** | |
| *For qualitative results[1]:*<br>All systematic reviews report null results only for this factor<br><br>*For quantitative results[2]:*<br>All systematic reviews report non-significant effect sizes for this factor | Stop: report no indication of an influence |
| *For qualitative results$_a$:*<br>Systematic reviews report mixed results for this factor<br><br>*For quantitative results$_b$:*<br>≥1 systematic review reports a non-significant effect ≥1 systematic review reports a significant effect size for this factor OR systematic reviews report significant effect sizes in different directions | Stop: report mixed findings |
| *For qualitative results$_a$:*<br>All systematic reviews report results in the same direction for this factor<br><br>*For quantitative results$_b$:*<br>All systematic reviews report significant effect sizes in same direction for this factor | +1 |
| ***Magnitude of effects (NA for qualitative results)*** | |
| All systematic reviews report no or negligible magnitude of effect for this factor | -1 |
| ≥ systematic review reports a small, medium or large magnitude of effect (i.e. not all report no or negligible magnitude of effect) for this factor | +1 |
| ***Imprecision (NA for qualitative results)*** | |
| ≤1 systematic reviews report high heterogeneity for this factor | -1 |
| All systematic reviews report small to moderate heterogeneity for this factor | +1 |

NA=not applicable. $_a$Qualitative results indicate that the results from the systematic reviews to this determinant included no meta-analyses and that we synthesized only qualitative results. $_b$Quantitative results indicate that the results from the systematic reviews to this determinant included meta-analyses and that we synthesized results from the meta-analyses. For systematic reviews the maximum number of points is +3 and minimum number of points is -2. For systematic reviews with meta-analysis the maximum number of points is +5 and the minimum points is -3. Cut-off criteria for quality of evidence decision: 1) -3 points to 0 points indicates insufficient evidence of an impact; 2) +1 points to +3 points indicates that there is evidence of an impact; 3) +4 points to +5 points indicates that there is a high certainty of an impact. In case, of null /non-significant results and significant findings or findings in different directions report that there are mixed findings. In case of only null results/non-significant results report that there is no indication of an impact.

## Appendix E. Reference list of excluded papers

### 1. No English Language (n=7)

- Chacon-Cuberos R, Zurita-Ortega F, Ramirez-Granizo I, Castro-Sanchez M. Physical Activity and Academic Performance in Children and Preadolescents: A Systematic Review. Review. *Apunts Educacion Fisica Y Deportes*. Jan-Mar 2020;(139):1-9.
- Gabrielle Cerqueira da S, Rodrigo Alves dos Santos S, Jorge Lopes Cavalcante N. Saúde mental e níveis de atividade física em crianças: uma revisão sistemática... Mental health and levels of physical activity in children: a systematic review. 2017;25(3):607-615. doi:10.4322/2526-8910.ctoAR0905
- Marti-Vilar M, Gonzalez-Sala F, Dominguez AJ. Prosocial Behaviour in Sports and Physical Activity: A Systematic Review. Review. *Revista Iberoamericana De Psicologia Del Ejercicio Y El Deporte*. 2019;14(2):171-178.
- Seiffer B, Wolf S. Exercise as a possible treatment option in attention deficit hyperactivity disorder. Current study situation and suggestions for specific exercise interventions / Sportliche Aktivitat als mogliche Therapieoption bei ADHS: Aktuelle Studienlage und Vorschlage fur spezifischere Sportinterventionen. *Psychotherapeut*. Jun 2020;65(3):156-159.
- Simoes H, Santos PM, Pereira B, Figueiredo A. Martial Arts and Combat Sports and the Bullying: a systematic review. Review. *Retos-Nuevas Tendencias En Educacion Fisica Deporte Y Recreacion*. 2021;(39):835-843.
- Wang G. Relation between sports activity and education of psychological health in college students. Review. *Chin J Clin Rehab*. 2006;10(24):140-142.
- סייביטינגוק, סייירוטום סידדמ לע הטארקה לש תיבויחה העפשהה סאה .ג-א לכימ ,ל למרכ סידליב ילופיט ילככ הטארקב שומישל לנויצר תווהל הלוכי סייסופיט סידלי לצא סייתרבחו היצנידרואוקב תיתוחתפתה הערפה סע? *Journal of the Israeli Physical Therapy Society (JIPTS)*. 2019;21(2):40-53.

### 2. Other review type (n=14)

- Arbesman M, Bazyk S, Nochajski SM. Systematic review of occupational therapy and mental health promotion, prevention, and intervention for children and youth. Article. *Am J Occup Ther*. 2013;67(6):e120-e130. doi:10.5014/ajot.2013.008359
- Biddle SJ. Exercise psychology. *Sport Science Review*. 1992;1(2):79-92.
- Bullock GS, Uhan J, Harriss EK, Arden NK, Filbay SR. The Relationship Between Baseball Participation and Health: A Systematic Scoping Review. Article. *J Orthop Sports Phys Ther*. 2020;50(2):55-66. doi:10.2519/jospt.2020.9281
- Cramer H, Lauche R, Dobos G. Characteristics of randomized controlled trials of yoga: a bibliometric analysis. *BMC Altern Med*. Sep 02 2014;14:328.

- Gubbels J, van der Stouwe T, Spruit A, Stams GJJM. Martial arts participation and externalizing behavior in juveniles: A meta-analytic review. Review. *Aggression Violent Behav*. 2016;28:73-81. doi:10.1016/j.avb.2016.03.011
- Gouttebarge V, Bindra A, Blauwet C, et al. International Olympic Committee (IOC) Sport Mental Health Assessment Tool 1 (SMHAT-1) and Sport Mental Health Recognition Tool 1 (SMHRT-1): towards better support of athletes' mental health. Article. *Br J Sports Med*. 2021;55(1):30-37. doi:10.1136/bjsports-2020-102411
- Hansell AH, Giacobbi PR, Voelker DK. A Scoping Review of Sport-Based Health Promotion Interventions With Youth in Africa. Article in Press. *Health Promot Pract*. 2020:1524839920914916. doi:10.1177/1524839920914916
- Johnson KE, Taliaferro LA. Relationships between physical activity and depressive symptoms among middle and older adolescents: A review of the research literature. *Journal for Specialists in Pediatric Nursing*. 2011;16(4):235-251. doi:10.1111/j.1744-6155.2011.00301.x
- Martin J, Liddell M, Roberts S, Greenwood E. Effective therapeutic interventions for Australian adolescents using alcohol and/or other drugs: a scoping review. Review. *Int J Ment Health Syst*. 2020;14(1)doi:10.1186/s13033-020-00425-z
- Rosen L, French A, Sullivan G. Complementary, holistic, and integrative medicine: Yoga. Review. *Pediatr Rev*. 2015;36(10):468-474. doi:10.1542/pir.36-10-468
- Ross G, Nelson R. Using Theater and Drama Interventions to Reduce Bullying in School-Aged Children. *THER RECREATION J*. 2014 4th Quarter 2014;48(4):334-336.
- Spruit A, van Vugt E, van der Put C, van der Stouwe T, Stams GJ. Sports Participation and Juvenile Delinquency: A Meta-Analytic Review. Article. *J Youth Adolesc*. 2016;45(4):655-671. doi:10.1007/s10964-015-0389-7
- Zhang ZJ, Chen WY. A Systematic Review of the Relationship Between Physical Activity and Happiness. Review. *Journal of Happiness Studies*. Apr 2019;20(4):1305-1322.
- Zarobe L, Bungay H. The role of arts activities in developing resilience and mental wellbeing in children and young people a rapid review of the literature. Review. *Perspect Public Health*. 2017;137(6):337-347. doi:10.1177/1757913917712283

**3. Age group not 0-21 year old (n=14)**

- Bridges L, Sharma M. The Efficacy of Yoga as a Form of Treatment for Depression. *J Evid Based Complementary Altern Med*. 10 2017;22(4):1017-1028.
- Grunseit AC, Richards J, Reece L, Bauman A, Merom D. Evidence on the reach and impact of the social physical activity phenomenon parkrun: A scoping review. *Prev Med Rep*. Dec 2020;20:101231.
- Lahart I, Darcy P, Gidlow C, Calogiuri G. The Effects of Green Exercise on Physical and Mental Wellbeing: A Systematic Review. 04 15 2019;

- Letton ME, Thom JM, Ward RE. The Effectiveness of Classical Ballet Training on Health-Related Outcomes: A Systematic Review. Article. *J Phys Act Health*. 2020;17(5):566-574. doi:10.1123/jpah.2019-0303
- Liu X, Clark J, Siskind D, et al. A systematic review and meta-analysis of the effects of Qigong and Tai Chi for depressive symptoms. *Complement Ther Med*. Aug 2015;23(4):516-534.
- Moore B, Dudley D, Woodcock S. The effect of martial arts training on mental health outcomes: A systematic review and meta-analysis. Review. *Journal of Bodywork and Movement Therapies*. Oct 2020;24(4):402-412.
- Nanthakumar C. Yoga for anxiety and depression – a literature review. *Journal of Mental Health Training, Education & Practice*. 2020;15(3):157-169. doi:10.1108/JMHTEP-09-2019-0050
- Noda S, Shirotsuki K, Nakao M. The effectiveness of intervention with board games: A systematic review. *BioPsychoSocial Medicine*. Oct 2019;13:22.
- Sharma M. Yoga as an alternative and complementary approach for stress management: a systematic review. Review. *J Evid Based Complementary Altern Med*. 2014;19(1):59-67. doi:10.1177/2156587213503344
- Sønderlund AL, O'Brien K, Kremer P, et al. The association between sports participation, alcohol use and aggression and violence: A systematic review. Review. *J Sci Med Sport*. 2014;17(1):2-7. doi:10.1016/j.jsams.2013.03.011
- Thompson Coon J, Boddy K, Stein K, Whear R, Barton J, Depledge MH. Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. Review. *Environ Sci Technol*. 2011;45(5):1761-1772. doi:10.1021/es102947t
- Williams E, Dingle GA, Clift S. A systematic review of mental health and wellbeing outcomes of group singing for adults with a mental health condition. Article. *Eur J Public Health*. 2018;28(6):1035-1042. doi:10.1093/eurpub/cky115
- Wolpert M, Dalzell K, Ullman R, et al. Strategies not accompanied by a mental health professional to address anxiety and depression in children and young people: a scoping review of range and a systematic review of effectiveness. Review. *Lancet Psychiatry*. 2019;6(1):46-60. doi:10.1016/s2215-0366(18)30465-6
- Yap AF, Kwan YH, Ang SB. A systematic review on the effects of active participation in rhythm-centred music making on different aspects of health. Review. *Eur J Integr Med*. 2017;9:44-49. doi:10.1016/j.eujim.2016.11.011

**4. No general population (n=14)**

- Axelsdóttir B, Biedilæ S, Sagatun Å, Nordheim LV, Larun L. Review: Exercise for depression in children and adolescents – a systematic review and meta-analysis. Article in Press. *Child Adolesc Ment Health*. 2020;doi:10.1111/camh.12438

- Balasubramaniam M, Telles S, Doraiswamy PM. Yoga on our minds: a systematic review of yoga for neuropsychiatric disorders. *Front Psychiatr*. 2012;3:117.
- Cahill SM, Egan BE, Seber J. Activity- and Occupation-Based Interventions to Support Mental Health, Positive Behavior, and Social Participation for Children and Youth: A Systematic Review. Article. *Am J Occup Ther*. 2020;74(2):7402180020p1-7402180020p28. doi:10.5014/ajot.2020.038687
- Cain M, Lakhani A, Istvandity L. Short and long term outcomes for culturally and linguistically diverse (CALD) and at-risk communities in participatory music programs: A systematic review. Review. *Arts Health*. 2016;8(2):105-124.
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# 5

# Associations of organized activities with risk of mental health problems in children

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## ABSTRACT

Previous studies conducted mainly among adolescents have found associations of participation in organized sport activities with a lower risk of mental health problems (MHP). Less research has been performed to primary school-aged children and to organized non-sport activities. Therefore the objective is to examine whether participation in organized sport-and non-sport activities is associated with risk of MHP in 4- to 12-year-olds. Data were used on 4,957 children from a cross-sectional population-based survey conducted between May-July 2018 in Rotterdam, the Netherlands. Associations of organized sport and non-sport activities and number of organized activities with risk of MHP were explored using logistic regression models adjusting for physical activity. Of all children, 57.5% participated in organized sport and 21.9% in organized non-sport activities. Children participating in organized sport activities have a lower risk of MHP (OR 0.65, 95%CI: 0.52, 0.80). Children participating in organized non-sport activities have a lower risk of MHP (OR 0.68, 95%CI: 0.52, 0.89). Children participating in 1 category (OR 0.61, 95%CI: 0.49, 0.76) and children participating in 2-5 categories of organized activities have lower total a lower risk of MHP (OR 0.48, 95%CI: 0.32, 0.71).

### Conclusions

Children participating in organized sport and non-sport activities have a lower risk of MHP. Participating in more categories of organized activities seems better for children's mental health.

## INTRODUCTION

Around 10-20% of children and adolescents experiences mental health problems (MHP).(1) First onset usually occurs during childhood or adolescence.(2) Early intervention can reduce or prevent mental health problems in later life.(1) Hence, gaining more insight in possible modifiable factors contributing to good mental health in childhood is important.

Participating in organized activities may contribute to good mental health in childhood.(3) Organized activities, depending on the breadth, intensity, duration, and engagement, could influence academic, social, psychological and behavioural outcomes of youth.(4) It may also lead to better emotion regulation and positive connections with peers, adults and the larger community.(5) Organized activities are characterized by having a certain structure, schedule, clearly defined goals and rules and are focused on skill-building.(4, 6) Examples of categories are sport, arts and community programs. The positive youth development theory (PYD), grounded in the socio-ecological theory, postulates that such activities could increase competence, confidence, connection, character and caring and consequently, positively contribute to mental health.(7-12)

Studies reported associations of participation in team and other types of organized sport activities with better youth mental health.(13, 14) Organized non-sport activities could also contribute to good child mental health.(3, 4, 6) Positive contributions to child mental health have been found but most earlier studies focused on adolescents.(15-17) Research to associations of participating in organized sport or non-sport activities with mental health in primary school-aged children is limited. Prevention in this particular age group possibly contributes to reducing the risk of MHP among adolescents. Therefore we aim to examine associations of participating in organized sport activities, organized non-sport activities and number of organized activities with risk of MHP in a population-based sample of 4- to 12-year-olds. We hypothesized that children participating in either organized sport or non-sport activities have a lower risk of MHP than children not participating in organized sport or non-sport activities.





## METHODS

### Study design

This cross-sectional study is performed using anonymous data from a Dutch Public Health survey carried out in 2018 by the municipal public health service in Rotterdam the Netherlands. This survey was conducted in the context of performing statutory tasks

(Public Health Act Netherlands). Observational research with anonymous data does not fall within the ambit of the Dutch Act on research involving human subjects and requires no approval of an ethics review board. The Dutch Code of Conduct for Medical Research allows using anonymous survey data for research purposes without an explicit informed consent.(18)

## Study population

The Dutch Public Health survey is meant to monitor the health of the inhabitants of Rotterdam in the context of performing statutory tasks. At the time the survey was administered Rotterdam included 61,020 inhabitants aged 4-12. Of these children 42.5% was Dutch, 11.2% had a Western migrant background and 46.4% had a non-Western migrant background. Random probability sampling from the municipal population register stratified by neighbourhood was performed to create a sample of parents/caregivers of 0- to 12-year-olds. Children living in healthcare institutions were excluded. Parents/caregivers received invitations for one child only. Hardcopy invitation letters included information about privacy, content, aim, anonymity and login details for the online questionnaire. A toll-free telephone number was provided for additional questions. Hardcopy questionnaires were enclosed with the first reminder and could be requested in Dutch, English or Turkish. The main caregiver filled out the questionnaire. Non-responders were contacted by telephone and were offered extra help in completing the questionnaire. Parents/caregivers were free to refuse participation by not filling out the questionnaire.

In total 7,702 parents/caregivers of 0- to 12-year-olds responded. The response rate was 34% and did not differ upon age or gender. For our study we used data about 4- to 12-year-olds (n=5,010). We excluded children with missing information about organized activities (n=28) or MHP (n=25) resulting in a final sample of 4,957 children.

## Measurements



### *Explanatory variables*

Organized activities participation was measured by the question: *'Which associations or organizations is your child a member of?'* Parents could choose between categories of organized activities. Multiple answers were possible:

1) Sport associations;
2) Singing, music or theater associations;
3) Scouting;
4) Craft club;
5) Different kind of organization;

6) None.

We computed three variables out of these items: organized sport activities, organized non-sport activities and number of categories of organized activities. Organized sport activities was based on item 1 and was categorized as: *'Organized sport activities participation*' and '*No organized sport activities participation*' using the latter as reference group. Organized non-sport activities was based on items 2, 3, 4 and 5 and categorized as: 'O*rganized non-sport activities participation*' and '*No organized non-sport activities participation*' using the latter as reference group. Number of categories of organized activities was based on all six items and categorized as: '*2-5 categories of organized activities',* '*1 category of organized activities'* and '*no organized activities'*, using the latter as reference group. This variable indicates the breadth of organized activities. We chose for this categorization to ascertain sufficient children in each category.

***Study outcome***

We computed the risk of MHP using the parent-reported Strengths and Difficulties questionnaire (SDQ) which was embedded in the public health survey. The SDQ is a validated questionnaire to measure risk of MHP and consists of five domains: emotional problems, conduct problems, hyperactivity, peer problems and prosocial behavior.(19, 20) The total difficulties score is was calculated by adding the scores of all domains except for prosocial behavior (range=0-40). We dichotomized the total difficulties score using age-dependent cut-off scores to either *'High risk of MHP* or a *'Normal score'* with the latter as reference group. For 4- to 7-year-olds a total difficulties score of ≥15 indicates risk of MHP and for 7- to 12-year-olds a cut-off is ≥14 indicates risk of MHP.(19, 20)

***Covariates***

Gender, age, family status, parental education, migrant status, perceived financial difficulties, current stressful life events and adequate physical activity were selected based on theory and previous research and were derived from the survey.(3, 4, 6, 15) Age was measured continuously in years and categorized as *'4-6 years'* '*7-9 years'* and *'10-12 years'*. Gender was measured as *'Girl'* or *'Boy'*. Family status was measured as*' Two-parent family'* or *'Single-parent or other type of family'*. Parental educational level was defined as highest parental educational level obtained and categorized as *'lower education*' (no education, primary school, or ≤4 years general secondary school), *'intermediate education'* (>4 years general secondary school or intermediate vocational training) and *'higher education'* (higher vocational training, university degree, or higher).(21) Parent-reported migrant status of the child was measured as *'Non-Western*' or *'Non-Dutch Western and Dutch*'. A Non-Western migrant status was assigned when the child itself or either one or both of the parents were born in a non-Western country. A Non-Dutch Western migrant

status was assigned when the child itself or either one or both of the parents were born in a Western-country different from the Netherlands.(22) Perceived financial difficulties was measured by the question: "Did you experience any difficulties in making ends meet in the past twelve months with your household income?" Perceived financial difficulties had four answer categories and was dichotomized as *'No financial difficulties'*(*'No'* and *'No but I have to think about my expenses')* and *'Financial difficulties'* (*'Yes a little'* and '*Yes*'). Current stressful life events was measured by eighteen stressful life events (e.g. '*Divorce of parents*') and categorized as either *'Yes'* or *'No'.* Adequate physical activity was measured by eight questions about five physical activity domains by commuting to school, by outdoor-play, by physical education or swimming lessons at school and by sport club membership. These questions were used to compute a dichotomous measure based on whether a child adhered to the Dutch norm of adequate physical activity (for 4- to 12-year-olds ≥60 minutes each day) as '*Yes'* or *'No'.*(23)

## Statistical analyses

Descriptive statistics were calculated and Chi-square and Mann-Whitney U tests were performed to test for differences between organized activities participation.

Multiple imputation (m=10) with the fully conditional specification method was used for missing values of covariates (total 0.7% ranging from 0.2%-3.9%) using data on explanatory variables, outcome variables and covariates as predictors. Sensitivity analyses using a complete-case dataset were conducted for comparison.

Multivariable logistic regression analyses were performed to examine associations of participating in organized sport and non-sport activities with the risk of MHP. We computed three models separate for organized sport activities and for organized non-sport activities and consecutively a fourth model which is a one combined model for both explanatory variables. Model 1 was a crude model. Model 2 was adjusted for age, gender, parental education, family status, perceived financial difficulties and migrant status of the child. Model 3 was additionally adjusted for current stressful life events and adequate physical activity. Model 4 is model 3 and additionally mutually adjusted for organized sport non-sport activities to examine independent associations (combined model).

Multivariable logistic regression analyses using the number of categories of organized activities with risk of MHP were also performed. Three models similar to model 1, 2 and 3 for organized sport and non-sport activities were computed.

To examine whether the impact differed upon groups with different characteristics interactions between age, gender, family status, migrant status, perceived financial difficulties and organized sport, non-sport and number of categories of organized activities were tested by adding the product terms of the explanatory variables with each of the potential effect modifiers separately to the full model (model 4 for organized sport and non-sport activities and model 3 for number of categories of organized activities)(4, 12, 15). Interactions between participating in organized sport and non-sport activities were tested likewise(4, 12). Interactions were considered present at a significance level of $p<0.05$ and none were found (Supplemental table 1).

Sensitivity analyses using a complete-case dataset were conducted for comparison. Missing-value analysis was performed using descriptive characteristics and Chi-square or Mann-Whitney U tests for differences between children without and with missing values.

Two-tailed analyses were performed using IBM SPSS statistics version 25 (SPSS Inc., Armonk, NY, USA) and p-values <0.05 were considered statistically significant.

## RESULTS

Table 1 shows the population characteristics. Of all children, 36% was 4-6 years, 38.4% was 7-9 years and 25.6% was 10≤12 years. The sample consisted of 48.4% girls. Of all children, 57.5% participated in organized sport activities, 21.9% participated in organized non-sport activities and 32.2% in none. In our sample, 55.3% participated in 1 category of organized activities, 12.5% participated in 2-5 categories of organized activities. Generally, more boys participated in organized sport activities and more girls participated in organized non-sport activities. Children with lower educated parents, with parents perceiving financial difficulties, and with a non-western migrant status participated less in organized sport activities.

Table 2 presents associations of organized sport and organized non-sport activities with risk of MHP. After adjustment for confounders, children participating in organized sport activities have a lower risk (OR 0.65, 95%CI: 0.52, 0.80) of MHP than children not participating in organized sport activities (model 4). Children participating in organized non-sport activities have a lower risk (OR 0.68, 95%CI: 0.52, 0.89) of MHP than children not participating in organized non-sport activities (model 4).

**Table 1.** Characteristics of the study sample.

| | Total population N=4,957 | No organized sport N=2,106 (42.5%) | Organized sport N=2,851 (57.5%) | p-value | No organized non-sport N=3,871 (78.1%) | Organized non-sport N=1,086 (21.9%) | P value |
|---|---|---|---|---|---|---|---|
| **Number of categories of organized activities** | | | | **<0.001** | | | **<0.001** |
| In 2-5 categories of organized activities | 618 (12.5%) | 41 (1.9%) | 577 (20.2%) | | 0 (0%) | 618 (56.9%) | |
| In 1 category of organized activities | 2,742 (55.3%) | 468 (22.2%) | 2,274 (79.8%) | | 22,74 (58.7%) | 468 (43.1%) | |
| No organized activities | 1,597 (32.2%) | 1,597 (75.8%) | 0 (0%) | | 1,597 (41.3%) | 0 (0%) | |
| **Age** | | | | **<0.001** | | | **<0.001** |
| 10-12 years | 1,269 (25.6%) | 436 (20.7%) | 833 (29.2%) | | 949 (24.5%) | 320 (29.5%) | |
| 7-9 years | 1,903 (38.4%) | 656 (31.1%) | 1,247 (43.7%) | | 1,423 (36.8%) | 480 (44.2%) | |
| 4-6 years | 1,785 (36.0%) | 1,014 (48.1%) | 771 (27.0%) | | 1,499 (38.7%) | 286 (26.3%) | |
| **Gender** | | | | **<0.001** | | | **<0.001** |
| Boy | 2,556 (51.6%) | 992 (47.1%) | 1,564 (54.9%) | | 2,141 (55.3%) | 415 (38.2%) | |
| Girl | 2,401 (48.4%) | 1,114 (52.9%) | 1,287 (45.1%) | | 1,730 (44.7%) | 671 (61.8%) | |
| **Parental education**[a] | | | | **<0.001** | | | **<0.001** |
| Higher | 2,447 (51.4%) | 788 (39.4%) | 1,659 (60.0%) | | 1,797 (48.4%) | 650 (62.0%) | |
| Intermediate | 1,536 (32.2%) | 748 (37.4%) | 877 (28.5%) | | 1,257 (33.8%) | 279 (26.6%) | |
| Lower | 782 (16.4%) | 465 (23.2%) | 317 (11.5%) | | 662 (17.8%) | 120 (11.4%) | |
| **Financial difficulties**[b] | | | | **<0.001** | | | 0.46 |
| No | 4,156 (84.7%) | 1,660 (79.9%) | 2,496 (88.3%) | | 3,241 (84.5%) | 915 (85.4%) | |
| Yes | 750 (15.3%) | 418 (20.1%) | 332 (11.7%) | | 594 (15.5%) | 156 (14.6%) | |
| **Migrant status**[c] | | | | **<0.001** | | | **<0.001** |
| Dutch | 2,267 (46.0%) | 709 (33.9%) | 1,558 (54.8%) | | 1,727 (44.8%) | 540 (50.0%) | |
| Western migrant | 646 (13.1%) | 297 (14.2%) | 349 (12.3%) | | 475 (12.3%) | 171 (15.8%) | |
| Non-Western migrant | 2,018 (40.9%) | 1,083 (14.4%) | 935 (32.9%) | | 1,650 (42.8%) | 368 (34.1%) | |
| **Family status**[d] | | | | **<0.001** | | | 0.88 |
| Two-parent | 3,689 (75.0%) | 71.7% (1,494) | 2,195 (77.4%) | | 2,882 (74.9%) | 807 (75.1%) | |
| Other | 1,232 (25.0%) | 590 (28.3%) | 642 (22.6%) | | 965 (25.1%) | 267 (24.9%) | |

**Table 1.** Characteristics of the study sample. (Continued)

| | Total population N=4,957 | No organized sport N=2,106 (42.5%) | Organized sport N=2,851 (57.5%) | p-value | No organized non-sport N=3,871 (78.1%) | Organized non-sport N=1,086 (21.9%) | P value |
|---|---|---|---|---|---|---|---|
| **Current stressful life events**[e] | | | | **<0.001** | | | 0.27 |
| No | 3,727 (75.4%) | 1,527 (72.7%) | 2,200 (77.3%) | | 2,924 (75.7%) | 803 (74.1%) | |
| Yes | 1,219 (24.6%) | 573 (27.3%) | 646 (22.7%) | | 938 (24.3%) | 281 (25.9%) | |
| **Physical activity**[f] | | | | **<0.001** | | | 0.55 |
| Adequate | 3,902 (79.0%) | 1,429 (68.2%) | 2,473 (87.0%) | | 3,040 (78.8%) | 862 (79.7%) | |
| Not adequate | 1,036 (21.0%) | 667 (31.8%) | 369 (13.0%) | | 816 (21.2%) | 220 (20.3%) | |
| **Risk of mental health problems** | | | | **<0.001** | | | **0.002** |
| No | 4,487 (90.5%) | 1,853 (88.0%) | 2,634 (92.4%) | | 3,477 (89.8%) | 1,010 (93.0%) | |
| Yes | 470 (9.5%) | 253 (12.0%) | 217 (7.6%) | | 394 (10.2%) | 76 (7.0%) | |

[a]192 missing (3.9%); [b]51 missing (1.0%); [c]26 missing (0.5%); [d]36 missing (0.7%); [e]11 missing (0.2%); [f]19 missing (0.4%). Chi-square tests were used to test for differences in categorical variables. Percentages are represented by column percentages. Valid percentages are reported. **Bold** indicates significance (p-value <0.05). For this study we used data from a survey conducted between May-July in Rotterdam, the Netherlands from 4,957 children aged 4- to 12-years old.

**Table 2.** Associations of organized activities with risk of mental health problems in 4,957 children.

| | Model 1 OR (95%CI) | Model 2 OR (95%CI) | Model 3 OR (95% CI) | Model 4 OR (95%CI) |
|---|---|---|---|---|
| **Organized sport activities** | | | | |
| Yes | **0.60 (0.45, 0.73)** | **0.60 (0.48, 0.73)** | **0.67 (0.54, 0.83)** | **0.65 (0.52, 0.80)** |
| No | ref | ref | Ref | ref |
| *Nagelkerke R-Square* | 0.012 | 0.084 | 0.109 | 0.106 |
| **Organized non-sport activities** | | | | |
| Yes | **0.66 (0.51, 0.86)** | **0.74 (0.57, 0.97)** | **0.73 (0.56, 0.95)** | **0.68 (0.52, 0.89)** |
| No | ref | ref | | ref |
| *Nagelkerke R-Square* | 0.005 | 0.077 | 0.106 | 0.113 |

**Bold** indicates significance (p-value <0.05). Model 1 is a crude unadjusted model. Model 2 is adjusted for sociodemographic variables (i.e. age (ref=10-12 years), gender (ref=boy), parental education (ref=higher), perceived financial difficulties (ref=no), family status (ref=two-parent), migrant status (ref=Dutch). Model 3 is model 2 and additionally adjusted for adequate physical activity (ref=yes), stressful life events (ref=no). Model 4 is model 3 and additionally (mutually) adjusted for organized sport or non-sport activities (i.e. independent association). Nagelkerke R-Square is reported based on imputation 10. For this study we used data from a survey conducted between May-July in Rotterdam, the Netherlands from 4,957 children aged 4-to 12-years old.

**Table 3.** Associations of categories of organized activities with risk of mental health problems in 4,957 children.

| | Model 1<br>OR (95% CI) | Model 2<br>OR (95% CI) | Model 3<br>OR (95% CI) |
|---|---|---|---|
| **Number of categories of organized activities** | | | |
| In 2-5 categories of organized activities | **0.40 (0.28, 0.58)** | **0.44 (0.30, 0.66)** | **0.48 (0.32, 0.71)** |
| In 1 category of organized activities | **0.58 (0.47, 0.70)** | **0.55 (0.44, 0.68)** | **0.61 (0.49, 0.76)** |
| No organized activities | ref | ref | ref |
| *Nagelkerke R-Square* | 0.008 | 0.089 | 0.114 |

**Bold** indicates significance (p-value <0.05). Model 1 is a crude unadjusted model. Model 2 is adjusted for sociodemographic variables (i.e. age (ref=10-12 years), gender (ref=boy), parental education (ref=higher), perceived financial difficulties (ref=no), family status (ref=two-parent), migrant status (ref=Dutch). Model 3 is model 2 and additionally adjusted for adequate physical activity (ref=yes), stressful life events (ref=no). Nagelkerke R-Square is reported based on imputation 10. For this study we used data from a survey conducted between May-July in Rotterdam, the Netherlands from 4,957 children aged 4-to 12-years old.

Table 3 presents associations of number of categories of organized activities with risk of MHP. Children participating in 1 (OR 0.61, 95%CI: 0.49, 0.76) or participating in 2-5 (OR 0.48, 95%CI: 0.32, 0.71) categories of organized activities have a lower risk of MHP than children not participating in organized activities (model 3).

Complete-case analyses yielded similar estimates (Supplemental tables 2-3). Participating in organized non-sport activities was non-significant in model 2 and model 3.

Comparisons between children with complete data (n=4,701) and with missing values (n=256) on included variables indicated differences for, family status, parental education, perceived financial difficulties, migrant status, risk of MHP, age, organized sport activities and number of categories of organized activities (Supplemental table 4).

## DISCUSSION

We demonstrated that 4- to 12-year-olds participating in organized sport or non-sport activities have a lower risk of MHP than children not participating in any organized activities. Children participating in 1 category of organized activities have a lower risk of MHP than children not participating. For children participating in 2-5 categories of organized activities the risk of MHP was even lower.

In our sample, 32.2% was not participating in any organized activity. Of all children 57.7% participates in organized sport activities and 21.9% in organized non-sport activities. This is consistent with a study among Canadian 6 to 12-year-olds in which 39% was not participating in organized activities.(17) The HBSC studies among nine nationally representative samples of 11-, 13- and 15-year-olds showed that 17.8% of the children was not participating in organized activities.(24) These children were somewhat older. (24)

We found associations of participating in organized sport activities with lower risk of MHP. Previous studies into organized sport activities already have reported associations with improved mental health in children, but most did not adjust for physical activity. (15, 25, 26) A consequence is that it is impossible to differentiate between benefits due to participating in organized sport activities or due to physical activity. We adjusted for physical activity and still found associations of organized sport activities with a lower risk of MHP. Another study among children also reported lower total difficulties scores and less internalising problems after adjustment for physical activity.(13) This supports our finding that participating in organized sport activities might contribute to good mental health besides by increasing physical activity. We did not study the type and characteristics of organized sport activities such as differences in competitiveness. Type and characteristics of organized sport activities might contribute differently or additionally to MHP in children.

We demonstrated similar associations of participating in organized non-sport activities with lower risk of MHP. This indicates that children can also benefit from participating in organized non-sport activities such as singing, music, theater, scouting or crafts. Most studies into organized activities in relation to mental health have focused on sport rather than other categories of organized activities. Also, previous research observed that organized non-sport activities might be beneficial for children's mental health but is inconclusive.(17, 24, 27) Among 27,121 Canadian 6- to 12-year-olds no differences in mental health were found between children who did or did not participate in educational programs, arts/music and individual sport.(17) A possible explanation may be that they included children participating in educational programs to meet parental expectations leading to lower levels of mental health.(17) Data from the HBSC studies also observed that both organized sport and non-sport activities contribute to better mental health. (24) We could not study distinct categories of organized non-sport activities due to low participation in some categories of organized non-sport activities.

In our sample, children participating in 2-5 categories of organized activities had the lowest risk of MHP. Previously, concerns were raised that more organized activities do

not contribute to better mental health but in fact could increase risk of MHP.(28) A higher number of categories of organized activities was hypothesized as too time-consuming, an indication of parental pressure, costing to much free time and being too competitive and thus leads to poor developmental outcomes. This is also known as the over-scheduling hypothesis.(28) In our study, most of the children participating in at least 2 categories of organized activities participated in 2 categories (11.1%) thus we could not study this. Other studies have reported positive contributions of participating in a higher number of categories or participating in more organized activities to mental health.(28, 29) This could be because it leads to more developmental opportunities in different contexts.(28, 29)

A possible explanation for the observed associations in our study is that the specific characteristics of organized activities (structure, scheduled meetings, clearly defined goals and rules, skill-building) affect the development process of children.(6) Children can build supportive relationships, feel included and learn positive social norms when participating in organized activities with other children. We did not measure whether organized activities where individual or group-based. The PYD theory mentions several features than can enhance positive development including the characteristics of organized activities.(30) The PYD theory suggests that the more of these features are present, the greater the contribution is to positive development and thus the greater the positive contribution to mental health.(7-11, 30)

Strengths of this study are the population-based setting, large sample size and validated questionnaire for assessment of risk of MHP. We adjusted for physical activity, showing that the associations of participating in organized sport activities with mental health possibly also originate from another pathway than through physical activity itself. This study also has some limitations. Due to the cross-sectional design no causation or temporal direction can be established. We adjusted for several covariates but residual confounding might be present because of incompletely or unmeasured confounders such as socioeconomic status indicators. Fewer disadvantaged children participated in organized activities and we could only adjust for parental education, perceived financial difficulties and migrant status. The survey data were not nationally representative possibly reducing the generalizability. The response rate was 34% which makes the study prone to selection bias, but low response rates do not automatically introduce bias in estimates or limit generalizability.(31) Moreover, surveys in the same Dutch city have similar response rates.(32) We have no information about the frequency, intensity or duration or if organized activities were individual or group-based.

## Public health implications

Preventive policies could contribute to good mental health by stimulating more children to participate in organized activities. Municipalities can increase the availability and amount of local clubs and associations and schools could offer additional extracurricular organized activities.(33) In addition, they could reduce financial barriers for participation by children of low income families through the supply of grants for free access.

## Future research

Future research, preferably longitudinal, should focus on studying the type, frequency, intensity, duration, setting (individual or group-based) and changes in participation of organized activities with mental health in children to provide more insight in possible pathways.

## Conclusions

Children participating in organized sport or non-sport activities have a lower risk of MHP compared to children not participating in organized activities. Children participating in more than one category or organized activities seem to have the lowest risk of MHP.

## SUPPLEMENTAL MATERIAL

**Table S1.** Tests for interaction effects.

| | p-value logistic regression |
|---|---|
| **Organized sport and non-sport activities** | |
| Organized sport activities*organized non-sport activities | 0.17 |
| **Organized sport activities** | |
| Organized sport activities *gender | 0.34 |
| Organized sport activities * age | 0.37 |
| Organized sport activities* family status | 0.62 |
| Organized sport activities * perceived financial difficulties | 0.88 |
| Organized sport activities * migrant status | 0.44 |
| **Organized non-sport activities** | |
| Organized non-sport activities* gender | 0.79 |
| Organized non-sport activities * age | 0.91 |
| Organized non-sport activities * family status | 0.25 |
| Organized non-sports activities * perceived financial difficulties | 0.17 |
| Organized non-sport activities* migrant status | 0.37 |
| **Number of categories of organized activities** | |
| Number of categories of organized activities *gender | 0.45 |
| Number of categories of organized activities * age | 0.29 |
| Number of categories of organized activities* family status | 0.71 |
| Number of categories of organized activities * perceived financial difficulties | 0.34 |
| Number of categories of organized activities * migrant status | 0.35 |

Tests for interaction were performed in model 4 (adjusted for age (ref=10-12 years), gender (ref=boy), parental education (ref=higher), perceived financial difficulties (ref=no), family status (ref=two-parent), migrant status (ref=Western) adequate physical activity (ref=yes), and stressful life events (ref=no) and additionally (mutually) adjusted for organized sport or non-sport activities (i.e. independent association)) for organized sport and organized non-sport activities and in model 3 (adjusted for age (ref=10-12 years), gender (ref=boy), parental education (ref=higher), perceived financial difficulties (ref=no), family status (ref=two-parent), migrant status (ref=Western) adequate physical activity (ref=yes), and stressful life events (ref=no)) for number of categories of organized activities. For this study we used data from a survey conducted between May-July in Rotterdam, the Netherlands from 4,957 children aged 4-12-years old.

**Table S2.** Complete-case associations of organized activities with risk of mental health problems in 4,701 children.

| | Model 1<br>OR (95%CI) | Model 2<br>OR (95%CI) | Model 3<br>OR (95%CI) | Model 4<br>OR (95% CI) |
|---|---|---|---|---|
| **Organized sport activities** | | | | |
| Yes | **0.62 (0.51, 0.76)** | **0.61 (0.49, 0.75)** | **0.69 (0.55, 0.87)** | **0.67 (0.54, 0.84)** |
| No | ref | ref | ref | ref |
| *Nagelkerke R-Square* | 0.010 | 0.076 | 0.103 | 0.105 |
| **Organized non-sport activities** | | | | |
| Yes | **0.72 (0.55, 0.93)** | 0.80 (0.61, 1.05) | 0.77 (0.59, 1.02) | **0.74 (0.56, 0.97)** |
| No | ref | ref | ref | Ref |
| *Nagelkerke R-Square* | 0.003 | 0.068 | 0.100 | 0.105 |

Complete-case dataset consists of n=4,701 children. **Bold** indicates significance (p-value <0.05). Model 1 is a crude unadjusted model. Model 2 is adjusted for sociodemographic variables (i.e. age (ref=10-12 years), gender (ref=boy), parental education (ref=higher), perceived financial difficulties (ref=no), family status (ref=two-parent), migrant status (ref=Western). Model 3 is model 2 and additionally adjusted for adequate physical activity (ref=yes), and stressful life events (ref=no). Model 4 is model 3 and additionally (mutually) adjusted for organized sport or non-sport activities (i.e. independent association). For this study we used data from a survey conducted between May-July in Rotterdam, the Netherlands from 4,957 children aged 4-12-years old.

**Table S3.** Complete-case associations of categories of organized activities with risk of mental health problems in 4,701 children.

| | Model 1<br>OR (95%CI) | Model 2<br>OR (95%CI) | Model 3<br>OR (95%CI) |
|---|---|---|---|
| **Number of categories of organized activities** | | | |
| In 2-5 categories of organized activities | **0.44 (0.31, 0.65)** | **0.48 (0.32, 0.71)** | **0.52 (0.35, 0.81)** |
| In 1 category of organized activities | **0.61 (0.49, 0.75)** | **0.57 (0.45, 0.71)** | **0.64 (0.51, 0.81)** |
| No organized activities | ref | ref | ref |
| *Nagelkerke R-Square* | 0.014 | 0.079 | 0.106 |

Complete-case dataset consists of n=4,701 children. **Bold** indicates significance (p-value <0.05). Model 1 is a crude unadjusted model. Model 2 is adjusted for sociodemographic variables (i.e. age (ref=10-12 years), gender (ref=boy), parental education (ref=higher), perceived financial difficulties (ref=no), family status (ref=two-parent), migrant status (ref=Western). Model 3 is model 2 and additionally adjusted for adequate physical activity (ref=yes), and stressful life events (ref=no). For this study we used data from a survey conducted between May-July in Rotterdam, the Netherlands from 4,957 children aged 4-12-years old.

**Table S4.** Comparison between children with complete and missing data.

| | | Population for analysis (n=4,701) | Population excluded for analysis (n=256) | P-value |
|---|---|---|---|---|
| **Gender** | Boy | 94.7% (2,421) | 5.3% (135) | 0.374 |
| | Girl | 95.0% (2,280) | 5.0% (121) | |
| **Family status** | Two-parent | 96.8% (3,570) | 3.2% (119) | **<0.001** |
| | Single-parent or other | 91.8% (1,131) | 8.2% (101) | |
| **Parental education** | Higher | 99.0% (2,422) | 1.0% (25) | **<0.05** |
| | Intermediate | 98.6% (1,514) | 1.4% (22) | |
| | Lower | 97.8% (765) | 2.2% (17) | |
| **Migrant status** | Dutch | 97.5% (2,210) | 57 (2.5%) | **<0.001** |
| | Western migrant | 93.3% (1,882) | 6.7% (136) | |
| | Non-Western migrant | 94.3% (609) | 5.7% (37) | |
| **Perceived financial difficulties** | No | 96.2% (3,996) | 3.8% (160) | **<0.01** |
| | Yes | 94.0% (705) | 6.0% (45) | |
| **Adequate physical activity** | Yes | 95.2% (3,713) | 4.8% (189) | 0.778 |
| | No | 95.4% (988) | 4.6% (48) | |
| **Current stressful life events** | No | 95.3% (3,552) | 4.7% (175) | 0.144 |
| | Yes | 94.3% (1,149) | 5.7% (70) | |
| **Risk of mental health problems** | No | 95.3% (4,276) | 4.7% (211) | **<0.001** |
| | Yes | 90.4% (425) | 9.6% (45) | |
| **Age** | | | | **<0.05** |
| | 10-12 years | 93.1% (1,182) | 6.9% (87) | |
| | 7-9 years | 95.2% (1,812) | 4.8% (91) | |
| | 4-6 years | 95.6% (1,707) | 4.4% (78) | |
| **Organized sport activities** | Yes | 95.9% (2,735) | 4.1% (116) | **<0.001** |
| | No | 93.4% (1,966) | 6.6% (140) | |
| **Organized non-sport activities** | Yes | 94.9% (1,031) | 5.1% (55) | 0.866 |
| | No | 94.8% (3,670) | 5.2% (201) | |

**Table S4.** Comparison between children with complete and missing data. (Continued)

| | | Population for analysis (n=4,701) | Population excluded for analysis (n=256) | P-value |
|---|---|---|---|---|
| **Number of categories of organized activities** | | | | **<0.01** |
| | In 2-5 categories of organized activities | 96.3% (595) | 3.7% 23 | |
| | In 1 category of organized activities | 95.4% 2,616 | 4.6% 126 | |
| | No organized activities | 93.3%) 1,490 | 6.7%) 107 | |

Row percentages are used. **Bold** indicates significance. Chi-square tests were used to test for differences in categorical variables. Valid percentages are reported. For this study we used data from a survey conducted between May-July in Rotterdam, the Netherlands from 4,957 children aged 4-12-years old.

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# 6

# Factors associated with parenting self-efficacy: A systematic review

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## ABSTRACT

**Aims:** To provide an overview of the parental, child, and socio-contextual factors related to general parenting self-efficacy (PSE) in the general population.

**Design:** Systematic review.

**Data sources**: Medline Ovid, Web of Science, Embase, and PsycINFO Ovid were systematically searched for studies published between January 1980-June 2020.

**Review Methods:** Studies were included if they described associations between factor(s) and PSE among parents of children aged 0-18 years old in the general population, and published in an English language peer-reviewed journal. Studies with participants from specific populations, studies describing the development of instruments for PSE, qualitative studies, reviews, theses, conference papers and book chapters were excluded. Belsky's process model of parenting guided the data synthesis.

**Results:** Out of 3,819 articles, 30 articles met the inclusion criteria. Eighty-nine factors were identified. There was evidence of associations between child temperament, maternal parenting satisfaction, parenting stress, maternal depression, household income, perceived social support and PSE. Evidence was inconsistent for an association of educational level, parity, number of children in the household and PSE in mothers. There was no evidence of an association for child gender, age, marital status and PSE in both mothers and fathers; ethnicity, age, employment status in mothers; household income in fathers; and educational level, parenting fatigue in parents.

**Conclusion:** A range of factors studied in relation to PSE was identified in this systematic review. However, the majority of the factors was reported by one or two studies often implementing a cross-sectional design.

**Impact:** There is some evidence for an association between some potentially modifiable factors and PSE in the general population, this information may be used by health and social professionals supporting child health and well-being. Future longitudinal studies are recommended to study parental, child and socio-contextual factors associated with PSE to inform the development of intervention strategies.

## INTRODUCTION

Parenting self-efficacy (PSE) underlies parents' confidence to raise their child (1, 2). The existing literature has highlighted associations between PSE and health outcomes in both parents and children (3-5). High PSE has been related to less depression, anxiety, stress in parents and fewer behaviour problems, better overall development in children (3, 5). Conversely, low PSE is considered to be a risk factor of negative parenting and a negative parent-child relationship (5). Apart from direct effects on parenting, PSE has also been shown to mediate the effects that parental depression and child temperament can have on parenting (6), and to buffer the impact of adversity brought on by an undesirable living environment (e.g. adverse housing conditions) (7). Therefore, identifying factors associated with PSE can be important for youth health care professionals, as well as for the development and tailoring of interventions aiming to support parents.

## BACKGROUND

As a subcategory of general self-efficacy, PSE has been defined as beliefs or judgements a parent holds regarding their capabilities to organize and execute a set of tasks related to parenting a child (1, 2). Three levels of PSE have been distinguished in previous literature: general, narrow domain, and task-specific (8, 9). General PSE refers to parents' perceptions of their ability to engage in the behaviours expected in their role as parents without focusing on specific tasks, i.e., general parenting situations across child ages (3). Narrow-domain PSE concentrates on parental perceived competence in one parenting domain, such as involvement in school-related activities. Finally, task-specific PSE refers to the confidence a parent has over a set of discrete parenting tasks, for example, breastfeeding and soothing a baby. In the current review, we study the general level PSE. This level of PSE is considered a less sensitive measure to assess changes in PSE compared with task-specific level PSE (1), however, it is applicable for a broader range of studies with a broader range of child ages (6, 10-15).

Previous studies have identified a broad range of factors associated with general PSE, including parenting psychological wellbeing (e.g., stress, depression) (16-20), social support, marital quality, child temperament, and child behavioural difficulties (6, 10-12). Other factors under study, including general health status, household income, socioeconomic status, birth weight, gestational weeks and parity, have thus far been inconsistently associated with PSE (6, 10-14).

Furthermore, existing reviews on factors associated with PSE have focused on specific populations (e.g., parents and /or children suffering from health problems) (21), or a specific developmental stage of children (e.g., infant, toddler) (22). Besides, most of the relevant literature has focused mainly on mothers or has not examined gender differences, even though studies have shown that parental gender plays an important role in daily parenting (16, 23-27).

### Theoretical framework

A process model of parenting was proposed by Belsky (28). This process model describes how factors from three domains can impact parenting: parental (e.g. developmental history, personality traits and psychological functioning), child (e.g. temperament, child behaviour) and socio-contextual (e.g. social network, marital quality, employment). Interplay between factors in and between these domains is possible (28). This model has been widely used in parenting-related studies (24, 29, 30).

## THE REVIEW

### Aims

The aim of this systematic review is to provide an overview of the results of quantitative studies on the parental, child, and socio-contextual factors associated with general PSE among parents with children aged 0-18 years in the general population.

### Design

*Registration*

The systematic review protocol was registered at PROSPERO (registration number: RD42019126737; URL*:* https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=126737*).*

### Search methods

In January 2019, a systematic literature search was conducted to identify relevant studies published after January 1980. An update of the search was then performed in June 2020. Articles were collected from electronic search engines and through a manual search based on reference articles. The following databases were included in the search: PsycInfo Ovid, MEDLINE Ovid, EMBASE, and Web of Science. Combinations of the following keywords were used: “parenting”, “self-efficacy”, “competence”, “confidence”, “determinant”, “predictor”, “socioeconomic factors” and “demography”. Often used synonyms for PSE were also included: “confidence”, “competence” and parental

"self-esteem" (31). The search strategy was adapted to each database, presented in supplementary file 1.

## Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were set to identify studies reporting associations between various factors with PSE in parents of children aged 0-18 years old in the general population.

The following inclusion criteria were used: (a) peer-reviewed article, (b) article published in English, (c) the study reported the association between at least one possible factor and PSE; PSE was reported as the outcome or mediator, (d) the study reported general level PSE; and (e) the study was performed among parents with children aged 0-18 years old from a general population sample. In relation to inclusion criteria number 4, studies sometimes used an alternative term to describe PSE such as parental confidence, self-agency, or self-definition (31). In this review, studies were included when they provided a definition of this alternative term in line with the definition of general level PSE (3). Studies that did not provide a clear definition, but used a valid instrument to assess general level PSE as reported by Črnčec (15) and Wittkowski (32), were also included.

Exclusion criteria were (a) the study was performed among parents at risk (e.g., parents/child with certain diseases or impairments), (b) the study included homogeneous subsamples of the population (e.g., only parents from low-income families),(c) the study described the development of instruments to measure PSE and (d) qualitative studies, review articles, theses, conference papers, and book chapters.

## Search outcomes

All references were exported and managed using Endnote X9. Title/abstract screening was performed by two reviewers independently using the abovementioned criteria.

Relevant articles were retrieved for full-text reading and further review by two reviewers (YF&MB). Status (included/excluded), study details (first author, year of publication, country), and reasons for exclusion were recorded in a designed access file. Disagreements were discussed with a third reviewer (AG/DW) until consensus was reached. The initial database and manual searches resulted in 3,344 unique titles without duplicate publications; and the updated search yielded 473 unique titles. In total, 147 full-text articles were identified, of which 30 unique studies met the inclusion criteria. A summary flow chart of the process of literature selection is presented in Figure 1.

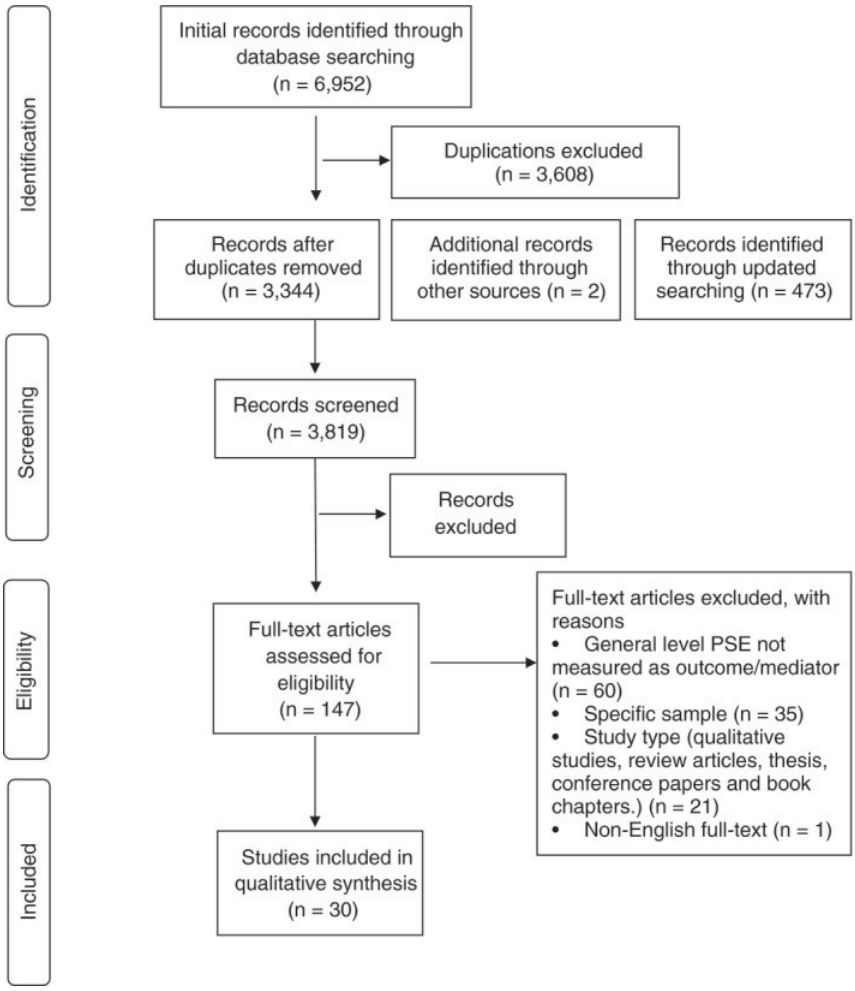


**Figure 1.** Flow chart for the selection of studies.



### *Quality appraisal*

The methodological quality of the included articles was assessed using the Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety of Fields (QualSyst) (33). The QualSyst is a 14-item tool that allows for methodological and bias assessment in quantitative and qualitative studies with varying study designs. Because of the observational design of the studies included in this review, item 5 (random allocation), 6 (blinding of investigators), and 7 (blinding of subjects) were removed from the QualSyst. Each item on the QualSyst received a score ranging from 0 to 2 to indicate whether the study fulfilled a criterion (0=no, 1=partially, and 2=yes). All scores were added up to create a total score. The total sum score was then converted into a percent-

age score (i.e. study total sum score divided by the total possible score of 22) and rated as "excellent" (scores of > 80%), "good" (70% - 79%), adequate (55 - 69%) and "low" (< 55%) (34). Two reviewers (YF&MB) assessed quality independently. Disagreements were resolved (AG/DW) via discussion until consensus was reached.

## Data Extraction

Data from individual studies were extracted and organized using an extraction form by one reviewer (YF) and then verified by another reviewer (MB). The extracted information included: first author, year of publication, study country, study design, population and characteristics, including sample size and demographic information, PSE instruments used, type and group (parental, child, socio-contextual) of the studied factors, and the reported associations between the studied factors and PSE.

From cross-sectional studies, the reported association between the factors and PSE at the same time point was extracted. From cohort studies, the association between the factors at baseline and PSE at the last follow-up was extracted. The associations between the studied factors and PSE were represented with "+" for a significant positive association, "-" for a significant negative association, and "0" for a null association. In studies with both univariate and multivariate results, the results from the multivariable associations were included when possible, otherwise the univariate results were used.

## Data Synthesis

Non-quantitative data synthesis was performed to summarize the evidence for an association of factors with PSE. Following Belsky's process model, factors were organized into three groups: parental, child, and socio-contextual factors. The factors within each group were further divided into subgroups (Figure 2).

The level of evidence was summarized per factor using a previously established method (35). The number of studies that reported the association of a specific factor with PSE was divided by the total number of studies that examined that factor. An association between a factor and PSE that was reported by 0 - 33%, 34 - 59% and 60 - 100% of individual studies, was represented using the labels: '0' for no association, '?' for an indeterminate/possible association, '+' for a positive association and '–' for a negative association. Double signs (i.e. '00', '??', '++' and '––') were given if the association between a factor and PSE was reported by four or more studies.

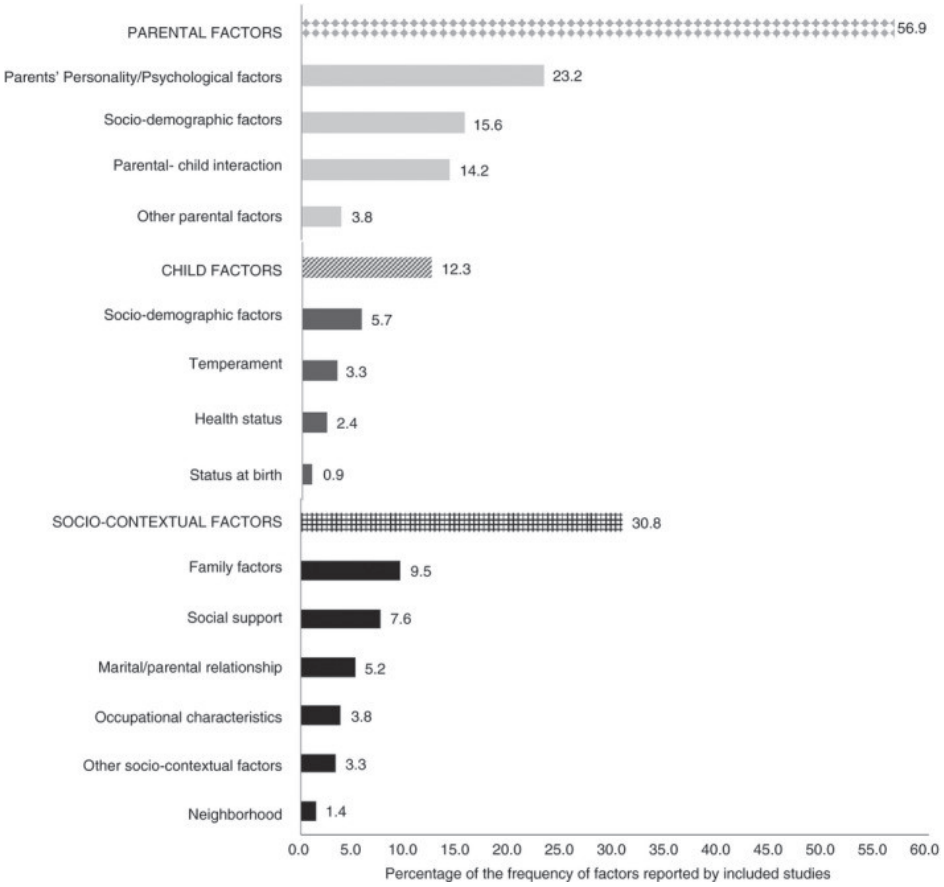


**Figure 2.** Distribution of the factors associated with PSE among parents of children aged 0-18 years old in the general population.

## RESULTS

### Characteristics of the included studies

The characteristics of the included studies are summarized in table 1. Detailed information of the included studies can be found in table S1**.** Three studies (10.0%) were published before the year 2000; six studies (20.0%) were published between 2000 to 2009, and twenty-one studies (70.0%) were published after 2010. Nearly half of the studies were conducted in North America (n=14, 46.7%). The other studies were carried out in Europe (n=6, 20.0%), Asia (n=7, 23.3%) and Australia (n=3, 10.0%). In total, 18 (60.0%) studies reported results using a cross-sectional design and 12 (40.0%) studies reported results from longitudinal studies.

**Table 1.** Characteristics of the studies included in the systematic review (N=30).

| Characteristics | N | Percentage (%) |
|---|---|---|
| **Study Design** | | |
| Cross-sectional | 18 | 60.0 |
| Longitudinal | 12 | 40.0 |
| **Year of publication** | | |
| <2000 | 3 | 10.0 |
| 2000-2009 | 6 | 20.0 |
| >=2010 | 21 | 70.0 |
| **Study Population** | | |
| Mothers only | 17 | 56.7 |
| Fathers only | 2 | 6.7 |
| Both [a] | 6 | 20.0 |
| Parents [b] | 5 | 16.7 |
| **Location** | | |
| North America | 14 | 46.7 |
| Europe | 6 | 20.0 |
| Asia | 7 | 23.3 |
| Australia | 3 | 10.0 |
| **Age period [c]** | | |
| Infant (0-1y) | 9 | 30.0 |
| Pre-school age (1-4y) | 9 | 30.0 |
| School age (4-12y) | 8 | 26.6 |
| School age (12-18y) | 2 | 6.7 |
| Not specific | 2 | 6.7 |
| **Measurement used** | | |
| Parenting sense of competence (PSOC) (Johnston & Mash, 1989) | 20 | 66.7 |
| Parenting Stress Index- Competence subscale (Abidin, 1997) | 4 | 13.3 |
| Parenting Self-Agency (PSA) (Dumka, Stoerzinger, Jackson, & Roosa, 1996) | 1 | 3.3 |
| Mother and Baby Scale (Brazelton & Nugent, 1995) | 1 | 3.3 |
| Parental Confidence Index (Mazarello Paes et al., 2015) | 1 | 3.3 |
| Self-perception of parental role questionnaire (MacPhee, Fritz, & Miller-Heyl, 1996) | 1 | 3.3 |
| Other PSE measurements (Holloway, Suzuki, Yamamoto, & Behrens, 2005; Suzuki, Holloway, Yamamoto, & Mindnich, 2009) | 2 | 6.7 |

[a] parents were included in the study and subgroup analysis were performed to analyze associations for mothers and fathers separately; [b] parents were included in the study and no subgroup analysis for mothers and fathers were performed; [c] based on the mean age of children; two studies: Henney, 2016 and Davidson Arad, McLeigh, & Katz, 2018 only reported range of the children these two studies were categorized into the not specific age group.

The sample sizes ranged from 33 to 1,750. Parents' ages ranged from 16 to 61 years old. Children's ages ranged from 0 to 18 years old, and the majority of children were between 0-6 years old (n=22, 73.3%). Half of the studies (n=17, 56.7%) were performed in a sample of only mothers from the general population, two (6.7%) studies were among fathers only. Eleven studies (36.7%) included both mothers and fathers, and five of them did not examine gender differences.

The most frequently used measurement for PSE was the Parenting Sense of Competence Scale (PSOC, n=20) (36), followed by the Parenting Stress Index (PSI)-Competence subscale (37) (n=4), Parenting Self-Agency (PSA, n=1)(38) , Mother and Baby scale (MABS) (n=1) (39), Parental Confidence Index (n=1) (40) and Self-perception of parental role questionnaire (SPPR)-Competence subscale (n=1) (41). Two studies employed self-made PSE assessment tools (42, 43).

## Quality of the included studies

Scores from the QualSyst checklist ranged from 50.0% to 90.9%, with a mean score of 74.7± 9.6% (Table S2). Of the 30 included studies, 12 (40.0%) were of excellent quality, 8 (26.7%) of good quality, 9 (30.0%) of adequate quality and 1 (3.3%) of low quality.

## Associations between factors and PSE

Results for mothers, fathers, and parents (i.e. irrespective of gender) are presented according to the process model of parenting (Table 2). In total 89 factors were reported. Hereof, 74.2% (n=66) of the factors were reported by one or two studies, 5.6% (n=5) of the factors were reported by three studies, and 20.2% (n=18) of the factors were reported by four or more studies. The most frequently studied factors were parental factors, followed by socio-contextual factors and child factors (Figure 2). In the current study, we mainly reported the level of evidence for the factors that were reported by three or more studies.

## Factors associated with PSE: parental factors

Forty-eight parental factors were identified, of which thirty-seven factors were only studied in one or two studies.



*Mothers*

Studies among mothers showed evidence for a negative association of maternal depression (4/7) and parenting stress (3/4) with PSE. Higher maternal satisfaction towards parenting (3/3) was shown to be associated with higher PSE. There was inconsistent evidence for a positive association between educational level (3/8) and parity (2/4) and PSE. There was no evidence for an association between maternal ethnicity (1/3),

**Table 2.** Associations between factors and general parenting self-efficacy in the general population of parents with children between 0-18 years, reported by studies included in this review (n=30).

| | Direction of Associations[a] | | | | |
|---|---|---|---|---|---|
| | Negative (-) | Null (0) | Positive (+) | n/N[b] | Summary[c] |
| **MOTHERS** | | | | | |
| **PARENTAL FACTORS** | | | | | |
| **Socio-demographic factors** | | | | | |
| Age | | Suzuki,2009; Troutman,2012; Cutrona & Troutman,1986; Ercegovac,2013; de Haan,2013; Katkic,2017 | Shrooti,2016 | 1/7 | 00 |
| Educational level (higher) | | Suzuki,2009; Holloway,2005; Hill & Tyson,2008; Ercegovac,2013; Katkic,2017 | Teti & Gelfand,1991; Cutrona & Troutman,1986; Shrooti,2016; | 3/8 | ?? |
| Ethnicity | | Hill & Tyson,2008 (African American vs European American); Murdock,2013 (white vs non-white); | Henney,2016 (black vs non-black) | 1/3 | 0 |
| **Parents' Personality/Psychological factors** | | | | | |
| Anxiety | Jover,2014 | Ogel-Balaban & Altan,2020 | | 1/2 | ? |
| Depression | Teti & Gelfand,1991; Cutrona & Troutman,1986; Jover, 2014; Gordo,2018; | Hill & Tyson,2008; Baker,2013; Hurwich-Reiss & Watamura,2019 | | 4/7 | -- |
| Fatigue | Studts,2019 | Dunning & Giallo,2012; | | 1/2 | ? |
| Depressed mood | | Cutrona & Troutman,1986 | | 0/1 | 0 |
| Parenting stress(higher) | Dunning & Giallo,2013, 2012; Gordo,2018; Mazur,2006 | Baker, 2013; | | 3/4 | -- |
| Parenting rewards | Gordo,2018; | | | 1/1 | - |
| Parenting stressors | Gordo,2018; | | | 1/1 | - |
| Parenting distress | | Mazur, 2006 | | 0/1 | 0 |
| Self-efficacy (Global level) (higher)[d] | | | Murdock, 2013; | 1/1 | + |

**Table 2.** Associations between factors and general parenting self-efficacy in the general population of parents with children between 0-18 years, reported by studies included in this review (n=30). (Continued)

| | Direction of Associations[a] | | | | |
|---|---|---|---|---|---|
| | Negative (-) | Null (0) | Positive (+) | n/N[b] | Summary[c] |
| Parenting self-efficacy (Task-specific level) (higher) | | | Teti & Gelfand, 1991 | 1/1 | + |
| Partners' parenting self-efficacy (higher) | | | Yang, 2020 | 1/1 | + |
| Parental competence (higher) | | | Knauth, 2000; Gordo, 2018; | 2/2 | + |
| Self-esteem (higher) | | Baker, 2013 | Shrooti, 2016 | 1/2 | ? |
| Parental affect | | Murdock, 2013 | | 0/1 | 0 |
| Psychological need satisfaction (relatedness) | | | de Haan, 2013 | 1/1 | + |
| Psychological need satisfaction (autonomy) | | | de Haan, 2013 | 1/1 | + |
| Personality (Dominance) | | | Henney, 2016 | 1/1 | + |
| Personality (Apprehension) | Henney, 2016 | | | 1/1 | - |
| Personality (Rule consciousness) | | Henney, 2016 | | 0/1 | 0 |
| Personality (Perfectionism) | | Henney, 2016 | | 0/1 | 0 |
| Personality (Emotional stability) | | Henney, 2016 | | 0/1 | 0 |
| Personality (Social boldness) | | Henney, 2016 | | 0/1 | 0 |
| Personality (anxiety) | Henney, 2016 | | | 1/1 | - |
| Personality (self-control) | | | Henney, 2016 | 1/1 | + |
| Personality (independence) | | | Henney, 2016 | 1/1 | + |
| Perceived Importance for family relationship | | Knauth, 2000; | | 0/1 | 0 |

**Table 2.** Associations between factors and general parenting self-efficacy in the general population of parents with children between 0-18 years, reported by studies included in this review (n=30). (Continued)

| | Direction of Associations[a] | | | | |
|---|---|---|---|---|---|
| | Negative (-) | Null (0) | Positive (+) | n/N[b] | Summary[c] |
| **Parental- child interaction** | | | | | |
| Parenting quality (Conflict resolution) (higher) | | | Ercegovac, 2013; | 1/1 | + |
| Parenting quality (Sense of acceptance) (higher) | | | Ercegovac, 2013 | 1/1 | + |
| Perception of child's vulnerability | Gordo, 2018 | | | 1/1 | + |
| Parenting behavior(control) | | Murdock, 2013; | | 0/1 | 0 |
| Parenting behavior (hostile or coercive) | Murdock, 2013 | | | 1/1 | - |
| Parenting behavior (supportive or engaged); | | Murdock, 2013 | | 0/1 | 0 |
| Readiness for pregnancy (ref: unplanned) | | | Shrooti, 2016 | 1/1 | + |
| Parenting satisfaction (higher) | | | Gordo, 2018; Mazur, 2006; Yang, 2020 | 3/3 | + |
| Parenting discipline (overreactive) | de Haan, 2013; | | | 1/1 | - |
| Parenting discipline (warmth) | | | de Haan, 2013; | 1/1 | + |
| Biased appraisals (negative cognitive error) | Mazur, 2006 | | | 1/1 | - |
| Biased appraisals (positive illusions) | | Mazur, 2006 | | 0/1 | 0 |
| **Other parental factors** | | | | | |
| Childhood memories (positive) | | | Holloway, 2005; Suzuki, 2009 | 2/2 | + |
| Physical activity | | | Studts, 2019 | 1/1 | + |
| Parity (non-primiparous) | | Cutrona & Troutman, 1986; Suzuki, 2009 | Troutman, 2012; Shrooti, 2016; | 2/4 | ?? |

**Table 2.** Associations between factors and general parenting self-efficacy in the general population of parents with children between 0-18 years, reported by studies included in this review (n=30). (Continued)

| | Direction of Associations[a] | | | | |
|---|---|---|---|---|---|
| | Negative (-) | Null (0) | Positive (+) | n/N[b] | Summary[c] |
| **CHILD FACTORS** | | | | | |
| **Socio-demographic factors** | | | | | |
| Age | | Suzuki, 2009;Holloway, 2005; Murdock, 2013 ; de Haan, 2013 ; Katkic, 2017;Studts, 2019 | | 0/6 | 00 |
| Gender (girls) | | Holloway, 2005; Murdock, 2013; Katkic, 2017 | de Haan, 2013; | 1/4 | 00 |
| General Health status (better) | | Baker, 2013 | | 0/1 | 0 |
| Child developmental difficulty(yes) | | | Katkic, 2017 | 1/1 | + |
| Behavior problems | Murdock, 2013; Studts, 2019 | | | 2/2 | - |
| Aggression (more) | de Haan, 2013; | | | 1/1 | - |
| Temperament (difficult) | Teti & Gelfand, 1991; Cutrona & Troutman, 1986; | Baker, 2013 | | 2/3 | - |
| Irritable (more) | | Troutman, 2012 | | 0/1 | 0 |
| Gestational week | Baker, 2013 | | | 1/1 | + |
| **SOCIAL CONTEXTUAL FACTORS** | | | | | |
| **Social Support** | | | | | |
| Perceived level of social support (higher) | | Baker, 2013; Katkic, 2017 | Cutrona & Troutman, 1986; Shrooti, 2016; Teti & Gelfand, 1991 | 3/5 | ++ |
| Number of support persons (more) | | | Shrooti, 2016 | 1/1 | + |
| Source of support | | Holloway, 2005 | | 0/1 | 0 |
| Spouses' support | | | Holloway, 2005; Suzuki, 2009; | 2/2 | + |
| Social support satisfaction(higher) | | Holloway, 2005 | | 0/1 | 0 |
| Friends support satisfaction (higher) | | | Suzuki, 2009 | 1/1 | + |

**Table 2.** Associations between factors and general parenting self-efficacy in the general population of parents with children between 0-18 years, reported by studies included in this review (n=30). (Continued)

| | Direction of Associations[a] | | | | |
|---|---|---|---|---|---|
| | Negative (-) | Null (0) | Positive (+) | n/N[b] | Summary[c] |
| **Marital /paternal relationship** | | | | | |
| Marital quality (higher) | | | Katkic, 2017 | 1/1 | + |
| Age at marriage | | | Shrooti, 2016 | 1/1 | + |
| Number of years married | | Cutrona & Troutman, 1986; | | 0/1 | 0 |
| Marital status (single) | | Dunning & Giallo, 2013; Murdock, 2013; | Ercegovac, 2013 | 1/3 | 00 |
| Partner violence (coercive control) | | Gou, 2019 | | 0/1 | 0 |
| **Occupation Characteristics** | | | | | |
| Employment (yes) | | Dunning & Giallo, 2013; Ercegovac, 2013; Katkic, 2017 | Shrooti, 2016 | 1/4 | 00 |
| Occupational prestige | | Hill & Tyson, 2008 | | 0/1 | 0 |
| **Family factors** | | | | | |
| Household income (higher) | | Murdock, 2013; | Teti & Gelfand, 1991; Shrooti, 2016 | 2/3 | + |
| Number of children (more) | | Baker, 2013; Holloway, 2005; Katkic, 2017 | Troutman, 2012; Ercegovac, 2013 | 2/5 | ?? |
| Spouses' Employment prestige | | Hill & Tyson, 2008; | | 0/1 | 0 |
| Spouses' educational level (higher) | | Hill & Tyson, 2008 | | 0/1 | 0 |
| Economic status (lower) | Hurwich-Reiss & Watamura, 2019 | Troutman, 2012; Dunning & Giallo, 2013; | | 1/3 | 0 |
| Family functioning (better) | | | Knauth, 2000; | 1/1 | + |
| Family size (bigger) | | | Jover, 2014; Ercegovac, 2013 | 2/2 | + |
| Family stress (higher) | | Hill & Tyson, 2008 | | 0/1 | 0 |

**Table 2.** Associations between factors and general parenting self-efficacy in the general population of parents with children between 0-18 years, reported by studies included in this review (n=30). (Continued)

| | Direction of Associations[a] | | | | |
|---|---|---|---|---|---|
| | Negative (-) | Null (0) | Positive (+) | n/N[b] | Summary[c] |
| Satisfaction with life (higher) | | Baker, 2013 | | 0/1 | 0 |
| **Neighborhood** | | | | | |
| Neighborhood quality(higher) | | Hill & Tyson, 2008 | | 0/1 | 0 |
| Neighborhood safety | | Hill & Tyson, 2008 | | 0/1 | 0 |
| Neighborhood social involvement (higher) | | Hill & Tyson, 2008 | | 0/1 | 0 |
| **Other socio-contextual factors** | | | | | |
| Religion | | Shrooti, 2016; | | 0/1 | 0 |
| Region | | Holloway, 2005; Shrooti, 2016; Ercegovac, 2013; Shrooti, 2016; | | 0/4 | 0 |
| Country of birth | | | Suzuki, 2009 (Janpan> USA) | 1/1 | |
| | | **FATHERS** | | | |
| **PARENTAL FACTORS** | | | | | |
| **Socio-demographic factors** | | | | | |
| Age | | de Haan, 2013 | | 0/1 | 0 |
| Educational level (higher) | | McBride, 1989; | Kwok & Li, 2015 | 1/2 | ? |
| Ethnicity | | Murdock, 2013(white vs non-white); | | 0/1 | 0 |
| **Parents' Personality/Psychological factors** | | | | | |
| Depression | Gordo, 2018; | | | 1/1 | - |
| Parenting stress (higher) | Gordo, 2018; McBride, 1989; | Kwok & Li, 2015 | | 2/3 | - |
| Parenting rewards | Gordo, 2018 | | | 1/1 | - |
| Parenting stressors | Gordo, 2018 | | | 1/1 | - |
| Self-efficacy (Global level) (higher) | | | Murdock, 2013; | 1/1 | + |

**Table 2.** Associations between factors and general parenting self-efficacy in the general population of parents with children between 0-18 years, reported by studies included in this review (n=30). (Continued)

| | Direction of Associations[a] | | | | |
|---|---|---|---|---|---|
| | Negative (-) | Null (0) | Positive (+) | n/N[b] | Summary[c] |
| Partner's parenting self-efficacy (higher) | | | Yang, 2020 | 1/1 | + |
| Parental competence (higher) | | | Gordo, 2018; Knauth, 2000 | 2/2 | + |
| Parental affect | | Murdock, 2013 | | 0/1 | 0 |
| Psychological need satisfaction (relatedness) | | | de Haan, 2013; | 1/1 | + |
| Psychological need satisfaction (autonomy) | | | de Haan, 2013; | 1/1 | + |
| Perceived Importance for family relationship | | Knauth, 2000 | | 0/1 | 0 |
| **Parental- child interaction** | | | | | |
| Beliefs on parental role | | Kwok & Li, 2015 | | 0/1 | 0 |
| Involvement | | Kwok & Li, 2015 | | 0/1 | 0 |
| Perception of child's vulnerability | | | Gordo, 2018 | 1/1 | + |
| Parenting behavior(control) | | Murdock, 2013; | | 0/1 | 0 |
| Parenting behavior (hostile or coercive) | | Murdock, 2013 | | 0/1 | - |
| Parenting behavior (supportive or engaged); | | | Murdock, 2013 | 1/1 | + |
| Parenting satisfaction (higher) | | | Gordo, 2018; Yang, 2020 | 2/2 | + |
| Parenting discipline (overreactive ), | de Haan, 2013; | | | 1/1 | - |
| Parenting discipline (warmth) | | | de Haan, 2013; | 1/1 | + |
| **CHILD FACTORS** | | | | | |
| Age | | Murdock, 2013; de Haan, 2013; McBride, 1989 | | 0/3 | 0 |

**Table 2.** Associations between factors and general parenting self-efficacy in the general population of parents with children between 0-18 years, reported by studies included in this review (n=30). (Continued)

| | Direction of Associations[a] | | | | |
|---|---|---|---|---|---|
| | Negative (-) | Null (0) | Positive (+) | n/N[b] | Summary[c] |
| Gender (girls) | | Murdock, 2013; McBride, 1989 | de Haan, 2013 | 1/3 | 00 |
| General Health status (better) | | | Salonen | 1/1 | + |
| Behavior problem | | Murdock, 2013 | | 0/1 | 0 |
| Aggression (more) | de Haan, 2013 | | | 1/1 | - |
| **SOCIAL CONTEXTUAL FACTORS** | | | | | |
| **Social Support** | | | | | |
| Financial Support | | | Kwok & Li, 2015 | 1/1 | '+ |
| Number of support persons (more) | | Kwok & Li, 2015 | | 0/1 | 0 |
| Spouses' support | | | Kwok & Li, 2015 | 1/1 | + |
| **Marital /paternal relationship** | | | | | |
| Number of years married | | Kwok & Li, 2015 | | 0/1 | 0 |
| Marital status (single) | | Murdock, 2013; Kwok & Li, 2015; | | 0/2 | 0 |
| Partner violence (coercive control) | Gou, 2019 | | | 1/1 | - |
| Parenting alliance | | | Kwok & Li, 2015 | 1/1 | + |
| **Occupation Characteristics** | | | | | |
| Employment (yes) | | Kwok & Li, 2015; | | 0/1 | 0 |
| **Family factors** | | | | | |
| Household income (higher) | | Murdock, 2013; McBride, 1989; Kwok & Li, 2015 | | 0/3 | 0 |
| Number of children (more) | | McBride, 1989 | | 0/2 | 0 |
| Spouses' Employment (yes) | | McBride, 1989 | | 0/1 | 0 |
| Spouses' income (higher) | | | Kwok & Li, 2015 | 1/1 | 0 |
| Family functioning (better) | | Knauth, 2000 | | 0/1 | ? |
| Family size (bigger) | | Kwok & Li, 2015; | | 0/1 | 0 |

**Table 2.** Associations between factors and general parenting self-efficacy in the general population of parents with children between 0-18 years, reported by studies included in this review (n=30). (Continued)

| | Direction of Associations[a] | | | | |
|---|---|---|---|---|---|
| | Negative (-) | Null (0) | Positive (+) | n/N[b] | Summary[c] |
| **PARENTS** | | | | | |
| **PARENTAL FACTORS** | | | | | |
| **Socio-demographic factors** | | | | | |
| Gender(female) | | Davidson Arad, 2018 | de Haan, 2009; Cooklin, 2012 | 2/3 | ? |
| Age | | de Haan, 2009; Cooklin, 2012 | | 0/2 | 0 |
| Educational level (higher) | | de Haan, 2009; Cooklin, 2012; Davidson Arad, 2018 | | 0/3 | 0 |
| **Parents' Personality/Psychological factors** | | | | | |
| Anxiety | | | Giallo, 2013 | 1/1 | + |
| Depression | Giallo, 2013 | | | 1/1 | - |
| Fatigue | Cooklin, 2012 | Giallo, 2013; Davidson Arad, 2018 | | 1/3 | 0 |
| Parenting stress (higher) | Giallo, 2013 | | | 1/1 | - |
| Sense of Hope | | | Davidson Arad, 2018 | 1/1 | + |
| Tolerance | | Davidson Arad, 2018 | | 0/1 | 0 |
| Personality (autonomy) | | | de Haan, 2009 | 1/1 | + |
| Personality (agreeableness) | | | de Haan, 2009 | 1/1 | + |
| Personality (conscientiousness) | | de Haan, 2009 | | 0/1 | 0 |
| Personality (extraversion) | | | de Haan, 2009 | 1/1 | + |
| Personality (emotional stability) | | | de Haan, 2009 | 1/1 | + |
| Coping strategy (active coping) | | | Cooklin, 2012 | 1/1 | + |
| Coping strategy (using emotional support) | | Cooklin, 2012 | | 0/1 | 0 |

**Table 2.** Associations between factors and general parenting self-efficacy in the general population of parents with children between 0-18 years, reported by studies included in this review (n=30). (Continued)

| | Direction of Associations[a] | | | | |
|---|---|---|---|---|---|
| | Negative (-) | Null (0) | Positive (+) | n/N[b] | Summary[c] |
| Coping strategy (using instrument support) | | Cooklin, 2012 | | 0/1 | 0 |
| Coping strategy (behavioral disengagement) | | Cooklin, 2012 | | 0/1 | 0 |
| Coping strategy (positive reframing) | | | Cooklin, 2012 | 1/1 | + |
| Coping strategy (planning) | | | Cooklin, 2012 | 1/1 | + |
| Coping strategy (humor) | | Cooklin, 2012 | | 0/1 | 0 |
| Coping strategy (acceptance) | | Cooklin, 2012 | | 0/1 | 0 |
| Coping strategy (self-blame) | Cooklin, 2012 | | | 1/1 | - |
| Parenting quality (Conflict resolution) | | | de Haan, 2009 | 1/1 | + |
| Involvement (more) | | | Giallo, 2013 | 1/1 | + |
| Perception of child's vulnerability | | Cooklin, 2012 | | 0/1 | 0 |
| Parenting satisfaction (higher) | | | Davidson Arad, 2018 | 1/1 | + |
| Experience with children | Cooklin, 2012 | | | 1/1 | - |
| **Others parental factors** | | | | | |
| General Health Status (better) | | Giallo, 2013; Cooklin, 2012; Davidson Arad, 2018 | | 0/2 | 0 |
| **CHILD FACTORS** | | | | | |
| Behavior problems | Finzi-Dottan, 2011 | | | 1/1 | - |
| Emotional Intelligence (higher) | | | Finzi-Dottan, 2011 | 1/1 | + |
| Temperament (difficult) | Giallo, 2013 | | | 1/1 | - |

**Table 2.** Associations between factors and general parenting self-efficacy in the general population of parents with children between 0-18 years, reported by studies included in this review (n=30). (Continued)

| | Direction of Associations[a] | | | | |
|---|---|---|---|---|---|
| | Negative (-) | Null (0) | Positive (+) | n/N[b] | Summary[c] |
| **SOCIAL CONTEXTUAL FACTORS** | | | | | |
| **Social Support** | | | | | |
| Perceived support need (higher) | Giallo, 2013<br>Cooklin, 2012 | | | 2/2 | - |
| Perceived level of social support (higher) | | | Finzi-Dottan, 2011 | 1/1 | + |
| **Marital /paternal relationship** | | | | | |
| Marital status (single) | | Cooklin, 2012 | | 0/1 | 0 |
| Marital quality (higher) | | Giallo, 2013 | | 0/1 | 0 |
| **Occupation Characteristics** | | | | | |
| Employment (yes) | | Cooklin, 2012; Davidson Arad, 2018 | | 0/2 | 0 |
| **Family factors** | | | | | |
| Economic status (lower) | | Cooklin, 2012 | Davidson Arad, 2018 | 1/2 | ? |
| Family size (bigger) | | Davidson Arad, 2018 | | 0/1 | 0 |
| Quality of life (higher) | | | Davidson Arad, 2018 | 1/1 | + |
| **Neighborhood** | | | | | |
| Neighborhood collective efficacy (higher) | | Davidson Arad, 2018 | | 0/1 | 0 |
| **Other socio-contextual factors** | | | | | |
| Religion | | Davidson Arad, 2018 | | 0/1 | 0 |

[a] Summarized data from all studies included in the review; [b] n represents the number of studies reporting a significant association, N represents the total number of studies investigating the association; [c] The association was labelled as '0' (no association), '?' (indeterminate/possible) and '+' or '–'(significant positive/negative association) if supported by 0–33%, 34–59% and 60–100% of individual studies, respectively. In addition, double signs ('00', '??', '++' and '––') were used to indicate if the factors were evaluated by 4 or more studies.

[d] Global self-efficacy refers to a persons' beliefs about being capable or confident to complete any given task, and parenting is one of these tasks. narrow-domain PSE concentrates on parental perceived competence in one parenting domain; task-specific PSE refers to the confidence a parent has over a set of discrete parenting tasks.

age (1/7) and PSE. Two studies found a positive association between positive maternal childhood development history and maternal PSE (42, 43). Regarding other maternal personality and psychological factors (24/26) studied, nine positive (6, 10, 11, 25, 40, 44), three inconsistent (13, 18, 45, 46), four negative (16, 40) and eight null associations (11, 12, 25, 40, 47) with PSE were observed. Evidence for factors related to maternal-child interaction was inconsistent and reported by a single study only (10, 11, 16, 23, 46-48).

*Fathers*

Studies among fathers showed evidence for a negative association between paternal parenting stress (2/3) and PSE. For the remaining paternal factors (22/26), nine positive (10, 11, 16, 25, 44), six negative (10, 16, 49, 50), six null (11, 25, 49, 50) and one inconsistent (23) associations were reported.

*Parents*

Studies among parents showed inconsistent evidence that mothers have higher PSE (2/3). There was no evidence for associations of parental educational level (0/3), fatigue (1/3) with PSE. For the remaining parental factors (24/27); 12 positive (27, 51-53), four negative (27, 51) and 10 null (27, 51-53) associations with PSE were reported.

## Factors associated with PSE: Child characteristics

Nine child factors were identified, of which three factors were only studied in one or two studies.

*Mothers*

For mothers, there was evidence for a negative association between difficult child temperament (2/3) and PSE. There was no evidence for an association between child age (0/6), child gender (1/4) and maternal PSE. Among other child characteristics, two positive(13, 54),two negative (10, 11, 55) and two null (14, 23) associations were reported.

*Fathers*

For fathers, there was no evidence of an association between child age (0/3), child gender (1/3) and paternal PSE. Evidence for other factors related to child characteristics and paternal PSE was inconsistent and studied by single studies.

*Parents*

For parents, there was evidence that parents of children with less behavioural problems, easier temperament, and more emotional intelligence have higher PSE. However, these findings were only studied by two studies (27, 56).

### Factors associated with PSE: Socio-contextual factors

Thirty-two socio-contextual factors were identified, of which 24 factors were only studied in one or two studies.

*Mothers*

For mothers, there was consistent evidence that mothers with a higher household income (2/3) and a higher perceived level of social support (3/5) have higher PSE. There was inconsistent evidence available for a positive association between the number of children (2/5) and maternal PSE. There was no evidence for an association between employment status (1/4), marital status (1/3), economic status (1/3) and maternal PSE. Three studies investigated the association between different sources of social support and satisfaction towards support, with three positive (42, 43, 46) and two null (42) associations with PSE reported. Of the 4/6 factors studied related to marital relationship and PSE, two positive (46) (54)and two null-associations (12, 57) were reported. One study reported a null association between occupational prestige and PSE (58). Regarding family factors, there was some evidence that better family health (1/1) and larger family size (2/2) were associated with higher PSE. And there was no evidence of an association between PSE and other family factors (13, 14, 18, 58, 59). One study found no associations between neighbourhood factors and PSE (58).

*Fathers*

For fathers, there was no evidence of an association between household income (0/3) and paternal PSE. Evidence for other factors related to social support, marital status (49), occupation (47), family (23, 25, 49, 50) and PSE was inconsistent. Most of these factors were reported by one study (Table 2).

*Parents*

For parents, evidence for factors related to social support, marital status, occupation, family, neighbourhood and PSE was reported by one or two studies; two positive (52, 56), one negative (27, 51), one inconsistent (51, 52) and six null- (27, 51, 52) associations with PSE were found.

## DISCUSSION

With this systematic review, we aimed to provide an overview of the available literature on factors associated with general parenting self-efficacy (PSE) among parents of children aged 0-18 years old in the general population. In total, 30 studies were included. Overall, the vast majority of the studies was performed among mothers only and fol-

lowed a cross-sectional design. Across studies a broad range of parental, child and social-cultural factors was evaluated in relation to PSE. Consequently, the evidence synthesis in this review was often limited to the fact that each factor was studied only in a small set of studies. Given these methodological considerations, this review concludes that based on the included studies, there is an association between parenting stress, depression, child temperament, household income, perceived social support and PSE. For the factors parental age, ethnic-background, employment, marital status, economic status, child age and child gender no association with PSE was evident. Inconsistent findings were reported for an association between parental educational level, parity, number of children living in the household and PSE.

## Parental factors and PSE

According to the process model of parenting, parental factors, compared with child and socio-contextual factors, may have the strongest impact on parenting behaviours; impacting parenting both directly and through social networks and the children (28). In this review, parental factors were studied in over 50% of the studies (10-14, 16-18, 23, 25, 40, 42, 43, 46-50, 57). Specifically, the parental demographic characteristics education level and ethnic background have been suggested to have a strong impact on PSE (6, 10-12, 14, 16, 18, 23, 40, 42, 43, 48-50, 57, 58). In the current review, three studies reported positive association between a higher education level and higher PSE, whilst five studies reported a null association (6, 12, 23, 42, 43, 46, 48, 58). Seo et al (60) have suggested that highly educated parents may actively obtain knowledge on parenting and may perceive more social support compared with lower educated parents, and in turn could be more confident in their role of parenting. More in line with our findings, they also argued that compared with highly educated parents, less educated parents could perceive less complexities in parenting, and thus are more confident in their role in parenting (60).

With regard to ethnic background, previous literature has reported cross-cultural differences in PSE (61, 62). In this review three studies included ethnic background as one of the factors under study in relation to general PSE (11, 40, 58). With regard to studies among mothers, one study reported an association between maternal ethnic background (i.e. Black vs non-Black) (Henney, 2016) and general PSE, two studies reported no difference in PSE between African American and European American (58), white and non-white mothers (11). The assessment of ethnicity in these studied was mainly based on country of birth and immigration status (11, 40, 58), therefore potentially reflects only part of cultural background (63). Cultural differences in PSE may relate to different attributions, attitudes and beliefs in parenting, which in turn could impact parental confidence in parenting (49, 61, 62). Therefore, the association between ethnic background

and PSE might be mediated by aspects of parenting, for example parenting warmth (58). More studies are recommended to assess cultural background and the relation with parenting and PSE.

Besides parental demographic factors, parental psychological factors are reported to impact parenting (28). Especially, depression and stress are often studied (64). In line herewith, this review observed evidence among included studies for an association between higher maternal depression and lower PSE (6, 12, 16, 17) as well as an association between higher parental stress and lower PSE (16, 18, 47, 50). It is reasonable to hypothesize that parents who suffer from depression and (or) parenting stress may find parenting more demanding; engaging in daily child-rearing activities to meet a child's needs can be more challenging than usual (27, 51). The consistent findings for parental depression and stress, underline the importance for health professionals to monitor the health and well-being of a family to be able to provide appropriate support.

Finally, parental developmental history, e.g. the experiences of parents in their own childhood with regard to their parents' parenting, has been highlighted as an important factor in shaping parenting (28). Parenting, or aspects of parenting behaviour, might be transmitted across generations (65). Two studies were identified in this review evaluating the association between childhood memories of parental warmth and support and PSE (42, 43). Both studies reported a positive association between warm childhood memories and PSE. Other aspects of parental developmental history were not reported upon but might be relevant for inclusion in future research.

## Child factors and PSE

In this review the associations between child factors and PSE were less often studied compared with parental and socio-contextual factors; 9 (10.1%) out of the 89 studied factors. The child factors most often studied, besides child age, were child behaviour problems and temperament. (6, 10-14). There was evidence for a negative association between a child's difficult temperament and PSE (6, 10, 12, 13). For example, de Haan et al used the Child Behaviour Checklist and observed that parents of children who are more aggressive had lower PSE(10). Murdock et al reported that one-point increase in problem behaviour total score would lower maternal PSE by 0.34 ($p<0.05$). These behavioural and temperament characteristics of a child could make certain elements of parenting more challenging, and decrease parenting self-efficacy. Youth health care providers monitoring child and family well-being should be aware of potential additional challenges in parenting, for parents of children with a difficult temperament of behaviour problems.

The included studies suggested that there is no association between child age and PSE of the parents. According to previous studies PSE is dynamic as parenting tasks vary by the developmental stage of the child, and parents learn new skills adapting to the changing needs of their children(1, 3). Over 70% of the studies included in this systematic review were performed among samples of children between 0 and 6 years and were analysed cross-sectional (3, 6, 11-14, 16, 18, 23, 25, 27, 42, 43, 46-50, 57). Hence, future longitudinal studies across multiple developmental stages of children are recommended to assess the association between child age and PSE.

## Socio-contextual factors and PSE

Belsky suggested that a positive marital relationship is supportive of competent parenting (28). It is likely that parents can get support and encouragement on parenting from their direct partners, which may help develop, maintain and increase parenting self-efficacy. We identified nine studies that included marital status or single/non-single parents, and reported no association with PSE (11, 12, 18, 23, 46, 49, 57). Only one study reported single mothers had lower PSE (48). A social support network may be equally as important for families as a marital relationship (28). A higher level of social support is a well-established predictor of optimal parenting practices and parent well-being (66). Parents may get advice and support on child-rearing from their partner, family, friends and social network, supporting parental perceived PSE. Besides, when feeling supported, parents may also experience less parenting stress and therefore have more confidence in their role of the parent (66, 67). The studies in this review suggested a positive association between parent perceived level of support and PSE (6, 12, 13, 46, 54). More specifically studies indicate that apart from perceived social support, the source, content and quality of the support could also be related to PSE (42, 43). Family structures have been becoming more diverse over the past decades (e.g., divorce, cohabitation, same-sex marriage has been increasing) (Livingston, 2014), studying family structure and the social relationships in relation to PSE is relevant.

## Mothers, fathers and PSE

Previous studies demonstrated that mothers and fathers might perceive their role as a parent differently (68, 69). Although the studies included in our review were mostly performed in samples of mothers only, there were a few that were performed in mixed samples (10, 11, 16, 23, 25, 57). From these studies two main conclusions can be drawn. First of all, studies suggest mixed evidence for a gender difference in overall level of PSE: two studies (16, 23) reported mothers having a higher PSE and three studies (10, 18, 57) reported comparable PSE between mothers and fathers. Second, when studying factors associated with PSE, studies suggest that certain factors are factors associated with PSE in similar directions, for both fathers and mothers (e.g. depression and parenting stress)

(10, 11, 16, 23, 25, 57). Others factors seem to be differently associated with PSE for fathers and mothers. For example, family functioning was suggested to be associated with maternal PSE only (25), and parenting stress with paternal PSE (24). However, these factors were only reported by one or two studies (10, 11, 16, 23, 25, 57) (Table S3). Additional research is recommended to study both maternal and paternal PSE and associated factors.

## Methodological considerations

The strengths of this systematic review include the large number of studies identified and included. This was possible by including studies that used alternative terms for PSE (i.e., parenting sense of competence, parenting satisfaction) to identify all relevant published papers. We present a data synthesis of available literature for the associations among mothers and fathers, adding to the existing literature. However, several limitations should also be addressed. First, publication bias cannot be ruled out as only peer-reviewed papers in the English language were included. This may lead to an under- or overestimation of the strength of the observed associations. Second, causalities cannot be ascertained as most of the studies followed a cross-sectional design. Moreover, a wide range of self-report PSE measures was used in the included studies. Although these measures are all used to measure PSE, there is a difference in, for example, the exact items used in these measures. Third, studies included were most often performed among samples obtained in developed countries, which may limit the generalizability of the results to other populations.

## Directions for future research

Three overall recommendations for future research can be formulated. First, longitudinal studies are recommended to evaluate the associations of factors with PSE over time. These studies could also provide insight in factors associated with PSE for parents of both younger and older children. Thus far, most studies are cross-sectional by design and focus on parents of children 0-6 years old. For each factor, researchers should consider carefully the concept that is being assessed by which definition (e.g., cultural background or immigration status). Second, parental, child and socio-contextual factors could interact with each other, or act as mediators or moderators in the association with parenting (28). In addition, studies have shown that the association between parenting and child development could also be bidirectional (70). Researchers are recommended to take these considerations, potentially guided by a theoretical framework, into account when developing the study design. Finally, most of the studies included in this review focused on mothers. In the past decades, fathers have taken on more active roles in caregiving (71). Researchers are recommended to continue efforts to include fathers when studying family health, well-being and factors associated with parenting and PSE.

## CONCLUSION

In this study, an overview of the evidence regarding the association of parental, child, and socio-contextual factors with PSE among parents of children aged 0-18 years old in the general population is provided. A range of factors studied in relation to PSE was identified in this systematic review. However, the majority of the factors was reported by one or two studies often implementing a cross-sectional design. There was some evidence for an association between potentially modifiable factors (e.g. parenting stress, depression and perceived social support) and PSE in the general population. This information may be used by health and social professionals supporting child health and well-being. Future longitudinal studies are recommended to study parental, child and socio-contextual factors associated with PSE to inform the development of intervention strategies.

## SUPPLEMENTAL MATERIAL

### Supplement 1: searching strategies

**embase.com**

((('competence'/de) AND ('child parent relation'/exp OR parent/exp OR 'child rearing'/de OR parenthood/de OR 'parental attitude'/de OR 'parental behavior'/de)) OR (((parent* OR mother* OR father* OR paternal* OR maternal* OR 'child rearing' OR childrearing) NEAR/6 (competenc* OR confiden* OR self-efficac*))):ab,ti) AND ('social determinants of health'/de OR 'determinant'/de OR 'predictor variable'/de OR 'prediction'/de OR forecasting/de OR 'income group'/exp OR 'educational status'/exp OR 'household income'/exp OR 'demography'/exp OR 'neighborhood'/exp OR 'family size'/exp OR 'ethnic group'/exp OR 'employment status'/de OR employment/de OR 'social status'/exp OR (determinant* OR predictor* OR predictive OR forecast* OR prediction* OR ((education* OR income OR socioeconomic* OR socio-economic* OR social) NEAR/3 (status OR level OR group* OR household OR background OR incongru* OR resource*)) OR (Psychosocial* NEAR/3 variable*) OR (economic* NEAR/3 hardship*) OR demograph* OR sociodemograph* OR neighborhood* OR neighbourhood* OR (Financial* NEAR/3 resource*) OR (family NEAR/3 (size OR large OR small)) OR (number NEAR/6 (children OR offspring)) OR ethnic* OR multiethnic* OR employment*):ab,ti) NOT ([Conference Abstract]/lim) AND [English]/lim

**Medline Ovid**

(((Mental Competency/) AND (exp Parent-Child Relations/ OR Child Rearing/ OR exp Parents/)) OR (((parent* OR mother* OR father* OR paternal* OR maternal* OR child rearing OR childrearing) ADJ6 (competenc* OR confiden* OR self-efficac*))).ab,ti.) AND (Social Determinants of Health/ OR Forecasting/ OR Educational Status/ OR Demography/ OR Residence Characteristics/ OR Family Characteristics/ OR Ethnic Groups/ OR Employment/ OR Social Class/ OR (determinant* OR predictor* OR predictive OR forecast* OR prediction* OR ((education* OR income OR socioeconomic* OR socio-economic* OR social) ADJ3 (status OR level OR group* OR household OR background OR incongru* OR resource*)) OR (Psychosocial* ADJ3 variable*) OR (economic* ADJ3 hardship*) OR demograph* OR sociodemograph* OR neighborhood* OR neighbourhood* OR (Financial* ADJ3 resource*) OR (family ADJ3 (size OR large OR small)) OR (number ADJ6 (children OR offspring)) OR ethnic* OR multiethnic* OR employment*).ab,ti.) AND english.la.

**PsycINFO Ovid**

(((Competence/) AND (exp Parent Child Relations/ OR Childrearing Attitudes/ OR Childrearing Practices/ OR exp Parental Attitudes/ OR exp Parents/)) OR (((parent* OR

mother* OR father* OR paternal* OR maternal* OR child rearing OR childrearing) ADJ6 (competenc* OR confiden* OR self-efficac*))).ab,ti.) AND (Prediction/ OR Educational Background/ OR Demographic Characteristics/ OR Neighborhoods/ OR Family Background/ OR "Racial and Ethnic Groups"/ OR Employment Status/ OR Social Class/ OR (determinant* OR predictor* OR predictive OR forecast* OR prediction* OR ((education* OR income OR socioeconomic* OR socio-economic* OR social) ADJ3 (status OR level OR group* OR household OR background OR incongru* OR resource*)) OR (Psychosocial* ADJ3 variable*) OR (economic* ADJ3 hardship*) OR demograph* OR sociodemograph* OR neighborhood* OR neighbourhood* OR (Financial* ADJ3 resource*) OR (family ADJ3 (size OR large OR small)) OR (number ADJ6 (children OR offspring)) OR ethnic* OR multiethnic* OR employment*).ab,ti.) AND english.la. NOT (news OR congres* OR abstract* OR book* OR chapter* OR dissertation abstract*).pt.

**Web of science**

TS=(((((parent* OR mother* OR father* OR paternal* OR maternal* OR "child rearing" OR childrearing) NEAR/5 (competenc* OR confiden* OR self-efficac*)))) AND ((determinant* OR predictor* OR predictive OR forecast* OR prediction* OR ((education* OR income OR socioeconomic* OR socio-economic* OR social) NEAR/2 (status OR level OR group* OR household OR background OR incongru* OR resource*)) OR (Psychosocial* NEAR/2 variable*) OR (economic* NEAR/2 hardship*) OR demograph* OR sociodemograph* OR neighborhood* OR neighbourhood* OR (Financial* NEAR/2 resource*) OR (family NEAR/2 (size OR large OR small)) OR (number NEAR/5 (children OR offspring)) OR ethnic* OR multiethnic* OR employment*))) AND DT=(article) AND LA=(english)

**Supplementary Table 1.** Detailed information about the characteristics of the studies included in the systematic review (N=30).

| Author, year | Study design | Comparison of | Country | Sample Size | Age (years)-parents mean (SD) [range] | Percentage girls (%) | Age (years)-children mean (SD) [range] † | Instruments used | Analysis | Parental factors ‡ | Child factors | Socio-contextual factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mothers Only Studies** | | | | | | | | | | | | |
| Dunning & Giallo, 2012 | CS | / | Australia | 1,022 | 34.51 (4.99) [18-50] | 46.9 | 2.59 (1.90) [0-6] | PSOC-Efficacy subscale | Path analyses | Parenting stress (-), Fatigue (0); | gender (0); | employment (0); family structure (0): sole or couple; socio-economic status (0) |
| Ercegovac, Ljubetic, & Pericic, 2013 | CS | / | Croatia | 468 | <30<br>31-40<br>>40 | x | 5.4 (3-6.8) | PSOC | Oneway ANOVA<br>correlation analysis | mother' age (0), employment (0), education (0), number of children (+), satisfaction (+), conflict resolution (+), acceptance (+) | | place of residence (-); marital status (ref: single-) parent family +), |
| Henney, 2016 | CS | / | America | 121 | 35 (7.8) [19-54] | x | [6-18] | Parental Confidence Index | regression analysis | Dominance (+); Apprehension (-) Rule; consciousness (0); Perfectionism (0); Emotional stability (0); Social boldness (0); anxiety (-); self-control (+); independence (+) | | ethnicity (black +) |

**Supplementary Table 1.** Detailed information about the characteristics of the studies included in the systematic review (N=30). (Continued)

| Author, year | Study design | Comparison of | Country | Sample Size | Age (years)-parents mean (SD) [range] | Percentage girls (%) | Age (years)-children mean (SD) [range] † | Instruments used | Analysis | Parental factors ‡ | Child factors | Socio-contextual factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Holloway, Suzuki, Yamamoto, & Behrens, 2005 | CS | / | Japan | 116 | x | x | 5.2 (0.40) [5-6] | self-made | correlation; regression analysis | childhood memories (+), husband support satisfaction (+), relative support satisfaction (0), mothers' education (0), | child age (0), number of children (0), gender (0) | Source of support: friends support (0), mothers' mothers' support (0), city of residence (0) |
| Hurwich-Reiss & Watamura, 2019 | CS | / | America | 127 | 31.64 (6.04) [18-44] | 43 | 2.18 (0.73) [0.75-3.67] | PSOC | regression analysis | parental depression (0); | | economic pressure (-); |
| Katkic, Morovic, & Kovacic, 2017 | CS | child with and without development disabilities (DD) | Croatia | 71 33 mothers of children with DD and 38 mothers of children without DD | 34.29 (5.17) [20-44] | 38 | children with DD:5.21 (3.09); children without DD: 5.34 (2.62) [1-13] | PSOC | regression analysis | maternal age (0); maternal educational level (0); number of children (0); | child gender (0); child age (0); child developmental difficulty (yes) (+); | maternal employment status (0); marital quality (+); social support (0) |
| Mazur, 2006 | CS | / | America | 72 | 33 (4.8) | x | 1.31 (0.32) [2-5] | PSOC-Efficacy subscale | regression analyses | negative cognitive error (-), positive illusions (0), parenting daily hassles (0), parenting stress (+), parenting distress (0), perceived parenting stress (-), parenting satisfaction (+), | | |

**Supplementary Table 1.** Detailed information about the characteristics of the studies included in the systematic review (N=30). (Continued)

| Author, year | Study design | Comparison of | Country | Sample Size | Age (years)-parents mean (SD) [range] | Percentage girls (%) | Age (years)-children mean (SD) [range] † | Instruments used | Analysis | Parental factors ‡ | Child factors | Socio-contextual factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| gel-Balaban & Altan, 2020 | CS | use Facebook vs no use | Turkey | 332 | 34.55 (5.44) [20-48] | x | 5.05 (4.27) | SPPR | regression analysis | anxiety (0) | | |
| Shrooti, Mangala, Nirmala, Devkumari, & Dharanidhar, 2016 | CS | / | Nepal | 290 | <=19<br>20-35<br>>35 | x | [0-1] | PSOC | regression analysis | Mothers' age (+), educational level (+), employment (yes +), readiness for pregnancy (planed +), age at marriage (+), per capita income (+), self-esteem (+), parity (non-primiparous +), residence urban (0), religion (0) | | social support (+), number of support persons (+) |
| Studts, Pilar, Jacobs, & Fitzgerald, 2019 | L, 3w FU | / | America | 137 | 32.0 (8.4) | 46 | [3-5] | PSOC | regression analysis | fatigue (-); physical activity (+); | child age (0); child disruptive behavior problems (-); | SES index (0); |
| Suzuki, Holloway, Yamamoto, & Mindnich, 2009 | CS | Japanese VS American | America | 235<br>121 American+114 Japanese mothers | Japan 35.61 (3.80) US 38.13 (4.24) [27-45] | 52.9 (American) VS 50 (Japanese) | American:5.03 (4.02); Japanese 6.89 (3.48) [5-6.12] | Self-made | regression analysis | age (0); education (0); | age (0); birth order (0); | country: (Japan: +); childhood parental support (+); satisfaction with husband' support (+); satisfaction with friends' support (+) |

**Supplementary Table 1.** Detailed information about the characteristics of the studies included in the systematic review (N=30). (Continued)

| Author, year | Study design | Comparison of | Country | Sample Size | Age (years)-parents mean (SD) [range] | Percentage girls (%) | Age (years)-children mean (SD) [range] † | Instruments used | Analysis | Parental factors ‡ | Child factors | Socio-contextual factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Teti & Gelfand, 1991 | CS | depressed VS no depressed | America | 86<br>48 depressed VS 38 nondepressed | [16-40] | x | 0.61 [0.25-1.08] | PSI-competence scale | Correlation analysis | maternal depression (-); task-specific PSE (+); maternal education (+); family income (+) | perceived infant difficulty (-); | social-marital support (+); |
| Baker, McGrath, Pickler, Jallo, & Cohen, 2013 | L, 6w FU | mothers of preterm infants Vs term infants | America | 70<br>49 term & 21 late preterm infants' mothers | 28.2 | x | [0-0.12] | PSOC | Correlation analysis | satisfaction with life (0), self-esteem (0), depression/ mood (0), stress (0), experience (0), | late preterm (-), infant wellbeing (0), perceived infant temperament (0), | support (0), |
| Cutrona & Troutman, 1986 | L, 3m FU | / | America | 55 | 27.3 [19-38] | x | 0.25 (0.03) | PSOC-Efficacy subscale | correlation; path analyses | age (0), number of years married (0), parity (primipara 0), number of years of education (+), mood (0), depression (-), | infant difficulty (-), | social support (+) |

**Supplementary Table 1.** Detailed information about the characteristics of the studies included in the systematic review (N=30). (Continued)

| Author, year | Study design | Comparison of | Country | Sample Size | Age (years)-parents mean (SD) [range] | Percentage girls (%) | Age (years)-children mean (SD) [range] † | Instruments used | Analysis | Parental factors ‡ | Child factors | Socio-contextual factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hill & Tyson, 2008 | L, | African American (N=54) European American (49) | America | T1: 103; T2: 86 | x | x | Fourth Grade | PSOC-Efficacy subscale | regression analysis | depression (0) | | Ethnicity: (American 0); Family stress (0); Neighborhood quality (0); Neighborhood social involvement (0); Neighborhood collective socialization (0); Neighborhood collective parenting (0); Mother's education (0); Mother's occupational prestige (0); Father's education (0); Father's occupational prestige (0); |
| Jover et al., 2014 | L, 8w FU | / | Spain | T1: 317; T2: 257 | 32.09 (4.44) [18-36] | 51.5 | 0.15 | MBS | regression analysis | postpartum depression (-); anxiety (-) | | Number of people at home (>2, +) |

**Supplementary Table 1.** Detailed information about the characteristics of the studies included in the systematic review (N=30). (Continued)

| Author, year | Study design | Comparison of | Country | Sample Size | Age (years)-parents mean (SD) [range] | Percentage girls (%) | Age (years)-children mean (SD) [range] † | Instruments used | Analysis | Parental factors ‡ | Child factors | Socio-contextual factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Troutman, Moran, Arndt, Johnson, & Chmielewski, 2012 | L, 16w FU | mothers of irritable and non-irritable infants | USA | 53 irritable 24 & non-irritable 29 | 31 [23-42] | 47.16 | [0.08-1.08] | PSOC -Efficacy subscale | ANCOVA (analysis of covariance) | age (0); Experience with children (+) | parity (non-primiparous, +); irritable (0) | seriocomic-status (0); |
| **Fathers Only Studies** | | | | | | | | | | | | |
| Kwok & Li, 2015 | CS | / | China | 1,750 | 39.09 (7.36) | x | 4.18 (1.2) [2-6] | PSOC-Efficacy subscale | Correlation; path analysis | age (+), household income (0), education level (+), employment status (0), marital status (0), years of marriage (0), number of children (0), (grand)parents live in house (0), domestic helpers (0), parenting alliance (+), marital satisfaction (+), fathers' beliefs on role (0), fathering stress (0), father involvement (0) | | spousal support (+), Spousal capital (+), receiving financial support (+), |

**Supplementary Table 1.** Detailed information about the characteristics of the studies included in the systematic review (N=30). (Continued)

| Author, year | Study design | Comparison of | Country | Sample Size | Age (years)-parents mean (SD) [range] | Percentage girls (%) | Age (years)-children mean (SD) [range] † | Instruments used | Analysis | Parental factors ‡ | Child factors | Socio-contextual factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| McBride, 1989 | CS | / | America | 94 | 35.6 [26-46] | x | 3.5 [1.6-4.8] | PSOC | Correlation analysis | Age (0), income (0), maternal employment (0), Fathers' education (0), parenting stress (+), child domain stress: adaptability (+)acceptability (+), perceptions of children's demandingness (+), moodiness (+), distractibility (+), reinforce (+), parent domain stress: depression (+), attachment to children (+), restriction (+), competence (+), isolation (+), relationship with their spouses (+), parent health (+), | Age (0), gender (0), number of children (0), | |

**Supplementary Table 1.** Detailed information about the characteristics of the studies included in the systematic review (N=30). (Continued)

| Author, year | Study design | Comparison of | Country | Sample Size | Age (years)-parents mean (SD) [range] | Percentage girls (%) | Age (years)-children mean (SD) [range] † | Instruments used | Analysis | Parental factors ‡ | Child factors | Socio-contextual factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parents Mixed Studies** | | | | | | | | | | | | |
| Cooklin, Giallo, & Rose, 2012 | CS | / | Australia | 1,276 | Mothers:34.3 (4.8) Fathers:36.7 (5.5) | x | [0-5] | PSOC | regression analysis | Fatigue (-), age (0), gender (0), number of child< 5 years (-), Coping strategies: active coping (+), using emotional support (0), using instrument support (0), behavioral disengagement (0), positive reframing (+), planning (+), humor (0), acceptance (0), self-blame (-), physical health (0), | | Education level (0), Relative Socio-Economic Disadvantage: SEIFA index (0), household type (single 0), social support satisfaction (0), social support need (-),employment (0), |
| Davidson Arad, McLeigh, & Katz, 2018 | CS | / | Israel | 198 | 34.1 [20-54] | x | <10 | PSOC-Efficacy subscale | correlation t test | perceived health (0), gender (0), work status (0): at home or not, volunteer activity (0), educational level (0), religiosity (0), parental satisfaction (+), hope (+), tolerance (0) | | collective efficacy (0), quality of life (+), perceived economic status (+), relative economic status (0), family size (0), |

**Supplementary Table 1.** Detailed information about the characteristics of the studies included in the systematic review (N=30). (Continued)

| Author, year | Study design | Comparison of | Country | Sample Size | Age (years)-parents mean (SD) [range] | Percentage girls (%) | Age (years)-children mean (SD) [range] † | Instruments used | Analysis | Parental factors ‡ | Child factors | Socio-contextual factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Finzi-Dottan, Triwitz, & Golubchik, 2011 | CS | ADHD child (71) vs normal' child (80 ') | Israel | 151 | for parents ADHD group: 40.86 (6.79); normal group: 39.86 (6.17) | x | ADHD group: [8.22-13.91]; normal group: [7.80-13.3] | PSOC | path analysis | | Emotional Intelligence (+); ADHD (-) | Social Support (+); |
| Giallo, Treyvaud, Cooklin, & Wade, 2013 | CS | / | Australia | 851 mothers and 131 fathers | mothers:34.31 (4.64) fathers:36.49 (4.99) [19-49] | 46.2 | [0-4] | PSOC | Correlation; path analysis | Parent Overall Health (0), stress (-), anxiety (+), depression (-), fatigue (0), marriage quality (0) involvement (+) | Difficult child temperament (-) | Perceived support need (-), |

**Supplementary Table 1.** Detailed information about the characteristics of the studies included in the systematic review (N=30). (Continued)

| Author, year | Study design | Comparison of | Country | Sample Size | Age (years)-parents mean (SD) [range] | Percentage girls (%) | Age (years)-children mean (SD) [range] † | Instruments used | Analysis | Parental factors ‡ | Child factors | Socio-contextual factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Murdock, 2013 | CS | / | America | mothers:49 fathers:33 | mothers:30.45 (5.13) [21-45] fathers:33.85 (6.55) [20-52] | x | 3.73 (0.73) [3-5] | PSA | Regression analysis | Mothers: general self-efficacy (+), negative affect (0), positive affect (0), hostile or coercive parenting behavior (-), supportive or engaged parenting behavior (0); parental control (0); Fathers: general self-efficacy (+), negative affect (0), positive affect (0), hostile or coercive parenting behavior (0), supportive or engaged parenting behavior (+); parental control (0), marital status (0), | Mothers: child behavior problems (-), age (0), gender (female: 0) Fathers: child behavior problems (0), age (0), gender (0) | Mothers: Ethnicity (white 0), family income (0), marital status (single:0), Fathers: ethnicity (0): white or not, family income (0), marital status (0), |
| Yang, Ke, & Gao, 2020 | CS | / | China | mothers:180 fathers:180 | Mothers:28.59 (3.70) Fathers:30.78 (3.97) | 45 | [0.12-0.67] | PSOC- Efficacy subscale | regression analysis | Mothers: parenting satisfaction (+); paternal PSE (+); Fathers: parenting satisfaction (+); maternal PSE (+) | | |

**Supplementary Table 1.** Detailed information about the characteristics of the studies included in the systematic review (N=30). (Continued)

| Author, year | Study design | Comparison of | Country | Sample Size | Age (years)-parents mean (SD) [range] | Percentage girls (%) | Age (years)-children mean (SD) [range] † | Instruments used | Analysis | Parental factors ‡ | Child factors | Socio-contextual factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| de Haan, Prinzie, & Dekovic, 2009 | L, 6y FU | / | Belgium | T1:594 mothers & 550 fathers T2: 466 mothers & 426 fathers | T1: mothers:36.1 [27.1,52] fathers:39.0 [27.9,61.1] T2: mothers [33.1,58]; fathers [33.6,64] | 50.3 | T1:7.5 [5-10.1]; T2: [11,16.1] | PSI-competence subscale | Regression analysis | gender (mother +); age (0), educational level (0), personality: extraversion (+), agreeableness (+), conscientiousness (0), emotional stability (+), autonomy (+); correlation: overactivity (-) warmth (+) | | |
| de Haan, Soenens, Deković, & Prinzie, 2013 | L, 8y FU | / | Belgium | mothers:430 fathers:430 | Mothers:36.6 [27-52] Fathers:41.5 [28-61] | 49.7 | T1:7.5 [6-9] T2: [12-15] T3: [14-17] | PSI-competence subscale | regression analysis | Mothers: parental sense of relatedness (+), parental sense of autonomy (+), overreactive discipline (-), warmth discipline (+); age (0); gender (0); Fathers: parental sense of relatedness (+), parental sense of autonomy (+), Parenting discipline (overreactive) (-), Parenting discipline (warmth ) (+); age (0); | Mothers: Age (0), gender (+): girls, aggression (-) Fathers: age (0), gender (+): girls; aggression (-) | |

**Supplementary Table 1.** Detailed information about the characteristics of the studies included in the systematic review (N=30). (Continued)

| Author, year | Study design | Comparison of | Country | Sample Size | Age (years)-parents mean (SD) [range] | Percentage girls (%) | Age (years)-children mean (SD) [range] † | Instruments used | Analysis | Parental factors ‡ | Child factors | Socio-contextual factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gou, Duerksen, & Woodin, 2019 | L, 2y FU | | Canada | mothers:74 fathers:72 | Mothers:29.8 (5.49); Fathers:32.03 (5.51) | x | t1:0; T2:1; T3:2 | PSOC | regression analysis | gender (0), | | Mothers: partner's coercive control (0), Fathers: coercive control of partner (-), |
| Gordo et al., 2018 | L, 11m FU | / | Spain | mothers:580 fathers:385 | Mothers:32.77 (5.11) Fathers:35.14 (5.07) | x | 0.66 (0.12) [0.42.1.22] | PSOC-Efficacy subscale | correlation; path analysis; | Mothers: Perception of child's vulnerability (-), depression (-), stress (-); rewards (-), stressors (-), parental competence (+), parental satisfaction (+) Fathers: gender (mothers: +), Perception of child's vulnerability (+), depression (-), stress (-); rewards (-), stressors (-), satisfaction (+), competence (+) | | |

**Supplementary Table 1.** Detailed information about the characteristics of the studies included in the systematic review (N=30). (Continued)

| Author, year | Study design | Comparison of | Country | Sample Size | Age (years)-parents mean (SD) [range] | Percentage girls (%) | Age (years)-children mean (SD) [range] † | Instruments used | Analysis | Parental factors ‡ | Child factors | Socio-contextual factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Knauth, 2000 | L, 8m FU | high risk vs low risk | America | mothers:114 fathers:114 | Mothers:29.3 (4.7) Fathers:31.8 (7.2) | x | 0.67 | PSOC | Regression analysis | Mothers: prenatal family functioning (+), family functioning at T2 (0), family functioning at T1 (-), parental competence at T1 (+), IMP (prenatal/ T1/T2) (0) Fathers: prenatal family functioning (0), family functioning at T1 (0), family functioning at T2 (0), parental competence at T1 (+), IMP (prenatal/ T1/T2) (0), | | |

Notes: Abbreviations: SD=Standard Definition=; PSOC=Parenting Sense of Competence; PSE=Parenting self-efficacy; PSI=Parenting Stress Index; PSA=Parenting Self-Agency measurement; MBS=Mother and Baby Scale; SPPR=Self-perception of Parent Role questionnaire; CS=cross-sectional; FU=follow-up; L=L; SES=socioeconomic status; y=year; m=month, w=week; X: not reported; /: not applicable; † age of children has been converted into years, if months or weeks were reported; ‡ + or - : statistically non- significant positive or negative association; 0: no association .

**Supplementary Table 2.** Results of the quality assessment of the studies included in the systematic review (N=30).

| Author and year | 1. Research question | 2. Study design | 3. Subject and variable selection | 4. Subject characteristics | 8. Exposures and outcome | 9. Sample size | 10. Analytic methods | 11. Estimate of variance | 12. Confounding | 13. Results in sufficient detail | 14. Conclusions support results | sums | weights† | Rank # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Baker et al., 2013 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 0 | 1 | 2 | 2 | 16 | 72.7 | good |
| Cooklin et al., 2012 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 19 | 86.4 | excellent |
| Cutrona & Troutman, 1986 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 0 | 1 | 2 | 2 | 15 | 68.2 | adequate |
| Davidson Arad et al., 2018 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 16 | 72.7 | good |
| de Haan et al., 2009 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 18 | 81.8 | excellent |
| de Haan et al., 2013 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 20 | 90.9 | excellent |
| Dunning & Giallo, 2012 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 0 | 1 | 2 | 2 | 17 | 77.3 | good |
| Ercegovac et al., 2013 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 0 | 2 | 2 | 2 | 16 | 72.7 | good |
| Finzi-Dottan et al., 2011 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 19 | 86.4 | excellent |
| Giallo et al., 2013 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 18 | 81.8 | excellent |
| Gordo et al., 2018 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 18 | 81.8 | excellent |
| Gou et al., 2019 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 17 | 77.3 | excellent |
| Henney, 2016 | 1 | 2 | 1 | 2 | 1 | 1 | 2 | 0 | 1 | 0 | 1 | 12 | 54.5 | adequate |
| Hill & Tyson, 2008 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 19 | 86.4 | excellent |
| Holloway et al., 2005 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 0 | 2 | 2 | 15 | 68.2 | adequate |
| Hurwich-Reiss & Watamura, 2019 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 18 | 81.8 | excellent |
| Jover et al., 2014 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 14 | 63.6 | adequate |
| Katkic et al., 2017 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 15 | 68.2 | adequate |
| Knauth, 2000 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 0 | 1 | 2 | 2 | 16 | 72.7 | good |

**Supplementary Table 2.** Results of the quality assessment of the studies included in the systematic review (N=30). (Continued)

| Author and year | 1. Research question | 2. Study design | 3. Subject and variable selection | 4. Subject characteristics | 8. Exposures and outcome | 9. Sample size | 10. Analytic methods | 11. Estimate of variance | 12. Confounding | 13. Results in sufficient detail | 14. Conclusions support results | sums | weights† | Rank # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kwok & Li, 2015 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 2 | 19 | 86.4 | excellent |
| Mazur, 2006 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 16 | 72.7 | good |
| McBride, 1989 | 1 | 1 | 0 | 2 | 1 | 1 | 1 | 0 | 1 | 1 | 2 | 11 | 50.0 | Low |
| Murdock, 2013 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 16 | 72.7 | good |
| Ogel-Balaban & Altan, 2020 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 0 | 1 | 2 | 1 | 15 | 68.2 | adequate |
| Shrooti et al., 2016 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 19 | 86.4 | excellent |
| Studts et al., 2019 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 17 | 77.3 | good |
| Suzuki et al., 2009 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 18 | 81.8 | excellent |
| Teti & Gelfand, 1991 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 0 | 2 | 2 | 2 | 14 | 63.6 | adequate |
| Troutman et al., 2012 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 0 | 1 | 1 | 2 | 15 | 68.0 | adequate |
| Yang et al., 2020 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 0 | 0 | 1 | 1 | 15 | 68.2 | adequate |

Notes: Each item was scored depending on to what degree the criterion was met: yes = 2 points, partial = 1 point, no = 0.; † study total sum score divided by the total possible score of 22; # A percentage score of >80%, 70%-80%, 55-69% and <55% was rated as "excellent", "good", adequate and "low", respectively.

**Supplementary Table 3.** Mothers, fathers and PSE, results from studies carried among parents with subgroup analysis (n=6).

| | | Direction of Associations † | | |
|---|---|---|---|---|
| | | **Negative (-)** | **Null (0)** | **Positive (+)** |
| **PARENTAL FACTORS** | | | | |
| **Socio-demographic** | | | | |
| | Gender(female) | | de Haan et al., 2013 ♀;Gou et al., 2019 ♀;<br>de Haan et al., 2013 ♂; Gou et al., 2019 ♂; | Gordo et al., 2018 ♀;<br>Gordo et al., 2018 ♂; |
| | Age | ***de Haan et al., 2013 ♂*** | ***de Haan et al., 2013 ♀;*** | |
| | Ethnicity (native) | | Murdock, 2013 ♀;<br>Murdock, 2013 ♂; | |
| **Parents' Personality/Psychological factors** | | | | |
| | Depression | Gordo et al., 2018 ♀;<br>Gordo et al., 2018 ♂; | | |
| | Parenting stress (higher) | Gordo et al., 2018 ♀;<br>Gordo et al., 2018 ♂; | | |
| | Parenting rewards | Gordo et al., 2018 ♀;<br>Gordo et al., 2018 ♂ | | |
| | Parenting stressors | Gordo et al.,2018 ♀;<br>Gordo et al., 2018 ♂ | | |
| | Parenting self-efficacy (Global level) (higher) | | | Murdock, 2013 ♀;<br>Murdock, 2013 ♂; |
| | Partners' parenting self-efficacy (higher) | | | Yang et al., 2020 ♀;<br>Yang et al., 2020 ♂ |
| | Parental competence (higher) | | | Knauth, 2000 ♀;<br>Gordo et al., 2018 ♀;<br>Gordo et al., 2018 ♂;<br>Knauth, 2000 ♂ |
| | Parental affect | | Murdock, 2013 ♀; Murdock, 2013 ♂ | |
| | Psychological need satisfaction (relatedness) | | | de Haan et al., 2013 ♀; de de Haan et al., 2013 ♂; |
| | Psychological need satisfaction (autonomy) | | | de Haan et al., 2013 ♀;<br>de Haan et al., 2013 ♂; |
| **Parental-child interaction** | | | | |
| | Perception of child's vulnerability | ***Gordo et al., 2018 ♀*** | | ***Gordo et al., 2018 ♂*** |

**Supplementary Table 3.** Mothers, fathers and PSE, results from studies carried among parents with subgroup analysis (n=6). (Continued)

| | | Direction of Associations † | | |
|---|---|---|---|---|
| | | **Negative (-)** | **Null (0)** | **Positive (+)** |
| | Parenting behavior(control) | | Murdock, 2013 ♀; Murdock, 2013 ♂; | |
| | Parenting behavior (hostile or coercive) | *Murdock, 2013 ♀* | ***Murdock, 2013 ♂*** | |
| | Parenting behavior (supportive or engaged) | | ***Murdock, 2013 ♀*** | ***Murdock, 2013 ♂*** |
| | Parenting satisfaction (higher) | | | Gordo et al., 2018 ♀; Gordo et al., 2018 ♀; Yang et al., 2020 ♀; Yang et al., 2020 ♂ |
| | Parenting discipline (overreactive ), | de Haan et al., 2013 ♀; de Haan et al., 2013 ♂; | | |
| | Parenting discipline (warmth ); | | | de Haan et al., 2013 ♀; de Haan et al., 2013 ♂; |
| **CHILD FACTORS** | | | | |
| | Age | | Murdock, 2013 ♀ ; de Haan et al., 2013 ♀ ; Murdock, 2013 ♂; de Haan et al., 2013 ♂; | |
| | Gender (girls) | | Murdock, 2013 ♀; Murdock, 2013 ♂; | de Haan et al., 2013 ♀; de Haan et al., 2013 ♂ |
| **Health** | | | | |
| | Behavior problems | ***Murdock, 2013 ♀;*** | ***Murdock, 2013 ♂*** | |
| | Aggression (more) | de Haan et al., 2013 ♀; de Haan et al., 2013 ♂ | | |
| **SOCIAL CONTEXTUAL FACTORS** | | | | |
| **Social Support** | | | | |
| | Marital status (single) | | Murdock, 2013 ♀; Murdock, 2013 ♂; | |
| | Partner violence (coercive control) | ***Gou et al., 2019 ♂*** | ***Gou et al., 2019 ♀*** | |
| **Occupation Characteristics** | | | | |
| **Family factors** | | | | |
| | Household income (higher) | | Murdock, 2013 ♀; Murdock, 2013 ♂; | |

**Supplementary Table 3.** Mothers, fathers and PSE, results from studies carried among parents with subgroup analysis (n=6). (Continued)

| | Direction of Associations † | | |
|---|---|---|---|
| | **Negative (-)** | **Null (0)** | **Positive (+)** |
| Family functioning | | ***Knauth, 2000 ♂*** | ***Knauth, 2000 ♀;*** |
| Perceived Importance for family relationship | | Knauth, 2000 ♀; Knauth, 2000 ♂ | |

Notes: † summarized data from studies performed in parents with subgroup analysis on mothers and fathers;
♀: Results for mothers; ♂: results for fathers;
Bold and italic indicates different directions of the associations between factors and PSE in mothers and fathers.

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# Part 2

# Interventions and policy programs to promote healthy lifestyles, health and well-being

7

# Interventions to increase the consumption of water among children: A systematic review and meta-analysis

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## ABSTRACT

The aim of this study was to conduct a systematic review and meta-analysis on the effectiveness of interventions to increase children's water consumption. A systematic literature search was conducted in seven electronic databases. Studies published in English before 18 February 2019 that evaluated any type of intervention that measured change in water consumption among children aged 2-12 years by applying any type of design were included. Of the 47 interventions included in the systematic review, 24 reported a statistically significant increase in water consumption. Twenty-four interventions (17 randomized controlled trials and seven studies with other controlled designs) were included in the meta-analysis. On average, children in intervention groups consumed 29 mL/d (confidence interval [CI]=13-46 mL/d) more water compared to children in control groups. This effect was larger in eight interventions focused specifically on diet (MD=73 mL/d, CI=20-126 mL/d) than in 16 interventions focused also on other lifestyle factors (MD=15 mL/d, CI=1-29 mL/d). Significant sub-group differences were also found by study setting and socioecological level targeted but not by children's age group, intervention strategy, or study design. In conclusion, there is evidence that, on average, lifestyle interventions can lead to small increases in children's daily water consumption. More research is needed to further understand the specific intervention elements that have the greatest effect.

## INTRODUCTION

Water is a healthy alternative to sugar-sweetened beverages (SSBs), of which high consumption has been associated with weight gain(1-3) and tooth decay(4, 5) in both children and adults. Guidelines therefore recommend introducing plain water when children are 6 months old and that it should be the principal source of hydration for children older than 1 year(4-6). In addition, the consumption of cow's milk for children older than 1 year is also recommended, because milk can contribute nutrients to children's diet(6). Evidence from longitudinal studies suggest a weight-reducing effect when consuming water instead of SSBs in children and adolescents(7) as well as in adults(8). Some controlled trials have also found that promoting water consumption among children reduces weight gain(9, 10). Different mechanisms might underlie these findings. The total amount of calories consumed may be reduced as water contains no calories, whereas SSBs do(11, 12). Another mechanism supported by Varsamis et al. may be that consuming SSBs is linked to elevated glucose responses and sustained elevation in plasma insulin during a day of prolonged sitting(13), which could lead to higher calorie intake in subsequent meals. A review by Daniels and Popkin suggested that the consumption of water instead of SSBs during or before meal times might reduce the energy intake during the meal(14).

Choosing to drink water as the main beverage is a habit which is likely formed in childhood(15, 16). The family environment is viewed as the principal place where dietary habits are shaped, especially during early childhood(17). Parents create the food environment in the home and often act as the role-models and gatekeepers for the dietary behaviours of their children(18-20). When children become older, the preschool and school environment can also influence the consumption behaviours of children(21, 22). Most interventions that target dietary and obesogenic behaviours have therefore been conducted in either the home- or school- environments; the latter, in particular, have received a lot of attention(23, 24). Some of these lifestyle interventions focus specifically on changing children's diet and the consumption of specific foods or beverages(25, 26) or multiple types of foods or beverages(27). Other interventions focus on changing both dietary behaviour and other obesogenic lifestyle behaviours such as physical activity and sedentary behaviour(28, 29).

In a previous systematic review by our team, we identified potentially modifiable factors that were associated with children's water consumption, these factors were the child's self-efficacy, parental self-efficacy, and parental- restrictive and encouraging feeding practices(30). By targeting such factors, lifestyle interventions may be able to promote the water intake among children. A positive effect of such lifestyle interventions has also

been found for related outcomes such as the reduction of SSB consumption(21, 22, 31) and reduction of weight gain(22, 32, 33). Although limited, recent evidence provides some indication that water consumption among children may indeed be promoted by interventions(24, 34). A systematic review by Cradock et al. on interventions to increase drinking water access and consumption in children younger than 5 years old found that 12 of the 18 studies that measured children's water consumption reported positive effects on water intake(34). A meta-analysis on the effectiveness of lifestyle (diet with/without other obesogenic lifestyle behaviours) interventions on SSB and water consumption among children and adults by Vargas-Garcia et al. only included seven studies that targeted children and found an increase of 67 mL/d in children's water consumption (24). However, to date, no comprehensive and rigorous evidence exists on the effectiveness of interventions to promote water consumption among children of preschool and primary-school age. The aim of this study was therefore to conduct a systematic review and meta-analysis on the effectiveness of interventions to increase the consumption of water among children aged 2-12 years. We focused on children older than 2 years because patterns of and recommendations for beverage intake among children aged 0 to 2 years change substantially for water, breastmilk, cow's milk, and juice(35).

## METHODS

### Search strategy

A systematic literature search for relevant studies was conducted in seven electronic databases: Embase, Medline Ovid, Web of Science, Cochrane, PsychINFO Ovid, CINAHL EBSCOhost, and Google Scholar on May 11, 2018(30). This search was updated in all seven electronic databases on February 18, 2019. A combination of key words was used in the search: (water or beverage* or drink* or related key words) and (child* or infant* or toddler* or related key words) and (intervention* or trial* or strateg* or effect* or promot* or related key words). The search strategy was adapted to each database. The full search strategies are presented in the Supporting Information. In addition to the database search, references of relevant articles were screened for other studies. The systematic review protocol for this study was registered in the PROSPERO registry under registration number CRD42019124808 on April 18, 2019.

### Selection process

The duplicates of records retrieved in the search were removed. Subsequently, two independent reviewers (C.F, and L.W. or M.B.) performed title and abstract screening of the remaining records in order to identify studies that met inclusion criteria. Then, copies of full text articles were ordered for all remaining studies, and full-text screening

was performed by two independent reviewers (C.F., and L.W. or M.B.). At both stages, disagreements that arose were discussed between them and, if necessary, resolved by consultation with a senior reviewer (H.R.).

## Inclusion and exclusion criteria

We applied specific inclusion criteria in the selection process. (a) We included participants with mean age between 2 and 12 years at baseline. (b) For the systematic review, we included any type of study design that allowed us to study the effectiveness of an intervention to increase the consumption of water among children, such as: randomized controlled trials (RCTs), non-RCTs, and other controlled- and non-controlled quasi-experimental designs. For the meta-analysis, we studied the mean difference between control group and intervention group in millilitres of water per day. Therefore, we could only include controlled studies that measured, within a specified time period, water consumption amount (millilitres, litres, grams, ounces, cups, glasses and servings) and/or frequency (consumption occasions, consumption frequency and consumption times). (c) We included any type of intervention strategy that aimed to promote water consumption among children. For studies that had a control group, the control group was defined as children who were not exposed to the intervention designed to promote water consumption. (d) We included the following categories of water: tap water, bottled drinking water, unflavoured sparkling water, flavoured water (nonsweetened), or any other source of safe drinking water. (e) We included studies that were published in an English language peer-reviewed journal anytime up to 18 February 2019.

The main exclusion criteria that were applied during the selection process were: (a) studies that only included participants from clinical populations (e.g. obesity, malnutrition, gastroenteritis) as we focused on the general population; (b) studies with data of less than 10 participants; and (c) studies that did not use human subjects. When more than one article was published on the same data set, the article with the longest follow-up period was used. Pilot studies; five in total(36-40), were included when a full trial of the intervention was not available.

## Data extraction

After discussion and consensus among the study team, a standardized data extraction form was developed. This form was used to extract data from the studies by one researcher (CF). The information that was extracted included: author, year and country of study, study design and name, intervention content (setting, strategy, socioecological level targeted, focus, frequency), control condition, length of intervention and follow-up time, population age and characteristics, number of participants in intervention and control groups and number of clusters (if applicable), how water consumption was mea-

sured, participation and retention rate, and outcome data: effect of the intervention on water consumption among children. Key data (intervention content and outcome data) were checked by a second researcher (MB). If available, published protocol papers were obtained and used during data extraction.

For the purpose of the meta-analysis, continuous data were extracted either as mean with standard deviation, or as adjusted mean difference with standard error. When studies had multiple follow-up time points, the time point with the longest follow-up time was chosen as suggested in the Cochrane Handbook(41). For two studies that had multiple intervention arms with different intervention elements(42, 43), we used the intervention arm with all intervention elements combined. For one study that had two slightly different intervention arms (44), the average of the two intervention arms was used as recommended in the Cochrane Handbook(41). For specific choices for each paper see Table S1. When data were missing, the authors were contacted to obtain the missing data.

## Risk of bias assessment

The risk of bias was assessed independently by two reviewers (CF and MB). For RCTs the Cochrane Collaboration's tool for assessing risk of bias was used(45). This tool assesses bias: in random sequence generation, in allocation concealment, in blinding of participants, personnel, and outcome assessors, due to incomplete outcome data, due to selective reporting and due to other reasons. For each domain of bias, the study was categorized as having 'low' or 'high' risk of bias. When it was not possible to determine the risk of bias for a certain bias domain due to missing information in the article, the domain was coded as 'unclear'. The most serious rating across these bias domains determined the overall risk of bias; e.g. if a study was categorized as having a 'low' risk of bias in five domains but a 'high' risk of bias in one domain, the overall risk of bias was high. For other designs, the Risk Of Bias In Nonrandomized Studies of Interventions (ROBINS-I) was used(46). The ROBINS-I tool assesses bias: due to confounding, in the selection of participants into study, in classification of exposures, due to departures from intended exposures, due to missing data, in measurement of outcomes and in selection of the reported result. For each domain, the study was categorized as having 'low, 'moderate', 'serious', or 'critical' risk of bias. For example, for the 'bias due to confounding' domain we assessed whether the study corrected for confounding variables, such as the child's sex and age. When it was not possible to define the risk of bias for a specific bias domain due to missing information, the domain was coded as 'no information'. Again, the most serious rating across bias domains defined the overall risk of bias. When there were discrepancies in the judgment of bias between the two reviewers, these were resolved through discussion.

## Analysis

For the qualitative synthesis we calculated the number of interventions that found a (statistically significant) positive effect on water consumption among children out of the total number of interventions included in the systematic review. We conducted a meta-analysis only with the subset of interventions with a controlled study design and appropriate outcome data available. A random-effects meta-analysis was conducted to account for the between-study variance using the mean difference in millilitres of water consumption at follow-up between the intervention group and control groups and the standard error of this difference. The overall mean difference and 95% confidence interval (CI) across all studies were estimated and forest plots were created that graphically display these results. The meta-analysis was conducted in Review Manager (version 5.3, Cochrane Library). The Cochrane Handbook was used for guidance regarding missing data and combining of data(41) and the Cochrane calculator was used for making calculations. Results from the most adjusted models were used, wherever available. If the mean difference in water consumption between the control group and intervention group at follow-up was not reported, the mean water consumption at follow-up was extracted separately for the intervention group and control group and the mean difference between intervention and control group was calculated. Using follow-up scores instead of change from baseline to follow-up scores is suggested to generate more conservative results in meta-analyses(33, 47).

If in the paper, water consumption was reported in a different quantity than in millilitres or within a different time period than one day, consumption was recalculated to millilitres of water per day. If the size of the portions was not reported in the paper we used a portion size of 225 ml per drink or consumption occasion, as portion sizes of the included papers which reported portion sizes varied between 200 ml to 250 ml(9, 48-51). If confidence intervals were presented instead of standard errors or standard deviations, these were calculated with the Cochrane calculator. When data was presented stratified by sub-groups, such as by sex, sub-groups were combined. If standard deviation at follow-up was missing but standard deviation at baseline was available, this was used. For specific calculations for each paper see Table S1.

The $I^2$ test was used to assess heterogeneity across studies; above 25% is considered low variance between studies, above 50% is considered moderate variance and above 75% is considered high variance(52). As specified in our protocol, subgroup analyses were performed with 1) potential moderators: 1a) type of intervention; focus (diet vs diet + other lifestyle factors) and strategy (education only vs other strategies + education vs only other strategies), 1b) socio-ecological level targeted by the intervention (individual level i.e. the child vs interpersonal level i.e. the parent or peer vs environmental level

vs all levels), 1c) children's age group targeted (2-5 years vs 6-12 years), and 1d) setting (school vs nonschool vs both school and nonschool) and 2) with type of study design (RCT vs other controlled designs). A sensitivity analysis was performed by re-estimating the overall effect in forest plots with papers using the mean water consumption and standard deviation in intervention group and control group at follow-up. A funnel plot was created of all studies and inspected visually.

## RESULTS

### Study selection

The inclusion and exclusion of articles is described using the preferred reporting items of systematic reviews and meta-analyses (PRISMA)(53) flow chart (Figure 1). A total of 35,912 records were identified through the database search. After removal of duplicates, a total of 19,346 records remained. After all rounds of screening, 39 articles were identi-

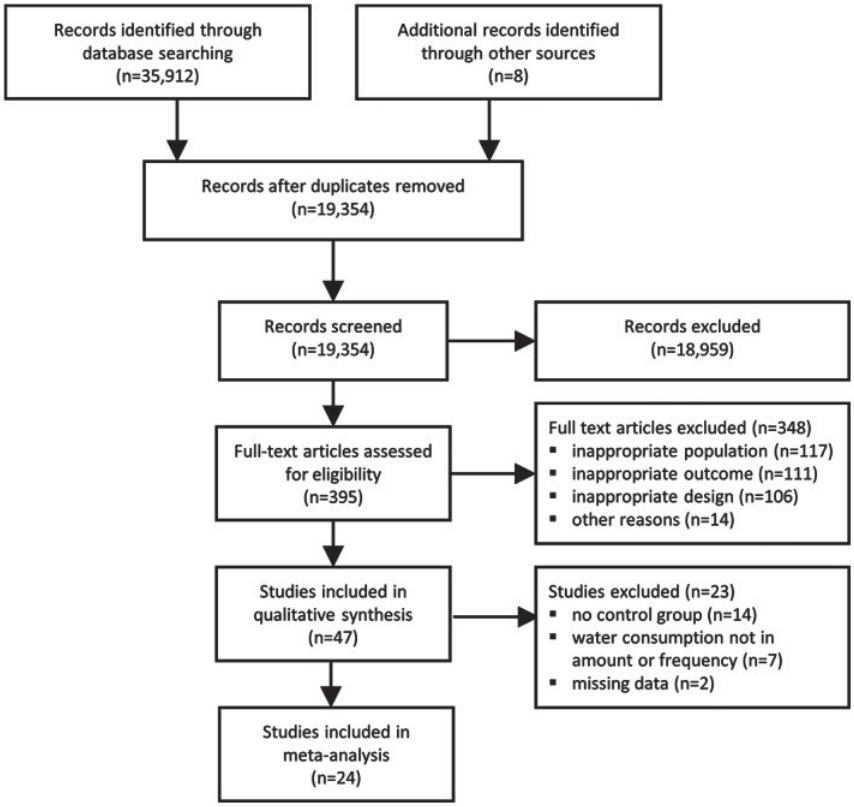


**Figure 1.** Flow chart for the selection of reviewed studies.

fied and included. Eight additional studies were identified by hand-searching references of included articles and other relevant articles, resulting in 47 articles that met the inclusion criteria and were included in the systematic review(9, 36-40, 42-44, 48-51, 54-87). Of these 47 studies, 24 studies could be included in the meta-analysis(9, 40, 42, 43, 48-51, 54, 60, 61, 63, 70, 72-75, 77, 80-85).

## Study characteristics

The overall characteristics of the studies that were included in the systematic review are shown in Table 1, specific details of each study are shown in Table S2. Of the 47 studies, the majority were based in the USA (24/47)(37-39, 43, 48, 50, 54-57, 62, 64, 66-68, 70, 72, 73, 75, 76, 78, 80, 81, 87) or in Europe (14/47)(9, 40, 42, 44, 51, 58-61, 74, 77, 83-85). All studies were published after 2000 and most (40/47)(36, 37, 39, 40, 42-44, 48-50, 54-70, 72, 74-81, 83, 84, 86, 87)were published after 2010. Most studies were RCTs (24/47)(40, 43, 44, 48, 50, 51, 54, 57, 59, 61, 63, 66, 69, 70, 74-77, 80, 81, 83-86); other designs were non-RCTs (9/47)(9, 39, 42, 60, 62, 67, 72, 73, 82), repeated cross-sectional controlled (1/47) (49), or non-controlled quasi-experimental study designs (13/47)(36-38, 55, 56, 58, 64, 65, 68, 71, 78, 79, 87).

Sixteen interventions targeted preschool aged children(37, 42, 43, 49, 58, 59, 61, 68, 69, 73-75, 77, 79, 81, 85) and the other interventions (31/47) targeted school-aged children(9, 36, 38-40, 44, 48, 50, 51, 54-57, 62-67, 70-72, 76, 78, 80-84, 86, 87). The majority of interventions were based in a school and/or preschool setting (28/47),(9, 36, 38-40, 48, 51, 55, 57-59, 62, 63, 65, 66, 69, 71, 72, 76-78, 80-82, 84-87) other settings were the community (7/47)(37, 56, 64, 67, 68, 70, 73)and home (4/47)(42, 44, 54, 74) and some interventions were based in multiple settings (8/47)(43, 49, 50, 60, 61, 75, 79, 83). Around half of the interventions focused on changing children's diet and other lifestyle factors (23/47)(37, 38, 43, 44, 48, 49, 54, 60-62, 69, 70, 72, 73, 75, 77, 79-82, 84, 86, 87), while some interventions focused specifically on children's diet (11/47)(55-59, 64, 65, 67, 71, 74, 85) or consumption of beverages (13/47)(9, 36, 39, 40, 42, 51, 62, 63, 66, 68, 76, 78, 83). Most studies (40/47)(9, 36-38, 40, 42-44, 48-50, 54, 56, 57, 59-66, 68-77, 79-81, 83-87) reported the use of theories for intervention development; only seven(39, 51, 55, 58, 67, 78, 82) studies did not report any theory. The majority of studies targeted the individual socioecological level ie, the child (37/47)(9, 36-38, 40, 42-44, 48, 50, 51, 54-56, 58-65, 68-72, 77-80, 82-87), and over half of the interventions targeted the interpersonal level ie, parents or peers (28/47)(37, 40, 42-44, 49, 50, 56, 58-64, 67-70, 73-75, 77, 79, 81, 83, 85, 87) or the environmental level (30/47)(9, 39, 42, 43, 49, 50, 56-58, 60-63, 65-69, 71, 75-84, 86). Education was used as a strategy in the majority of interventions (33/47)(9, 36-38, 42, 43, 48, 50, 51, 54, 55, 58-62, 64, 69-75, 77-79, 81-85, 87); other strategies that were used were restructuring the environment (21/47)(9, 39, 42, 49, 50, 57, 58, 60, 62, 66, 67,

**Table 1.** Characteristics of the studies included in the systematic review.

| Characteristics | n (%) of studies | |
|---|---|---|
| **Study location**[a] | | |
| USA | 24 | (51) |
| Europe | 14 | (30) |
| Australia/New-Zealand | 4 | (9) |
| Mexico/South America | 4 | (9) |
| Middle-East | 2 | (4) |
| **Year published** | | |
| ≥2010 | 40 | (85) |
| 2000-2009 | 7 | (15) |
| **Design** | | |
| Randomized controlled trial | 24 | (51) |
| Non-randomized controlled trial | 9 | (19) |
| Repeated cross-sectional controlled | 1 | (2) |
| Non-controlled quasi-experimental study | 13 | (28) |
| **Number of participants**[b] | | |
| <300 | 14 | (30) |
| 300-999 | 22 | (47) |
| ≥1000 | 8 | (17) |
| **Mean age children** | | |
| Preschool aged (2-5 years) | 16 | (34) |
| School aged (6-12 years) | 31 | (66) |
| **Intervention setting** | | |
| School/pre-school | 28 | (60) |
| Community | 7 | (15) |
| Home | 4 | (9) |
| Multiple | 8 | (17) |
| **Length of intervention** | | |
| ≤6 months | 25 | (53) |
| >6 months | 22 | (47) |
| **Focus of intervention** | | |
| Diet and other lifestyle factors | 23 | (49) |
| Diet | 11 | (23) |
| Beverages | 13 | (28) |

**Table 1.** Characteristics of the studies included in the systematic review. (Continued)

| Characteristics | n (%) of studies | |
|---|---|---|
| **Socioecological level targeted (multiple possible)** | | |
| Individual level (child) | 36 | (77) |
| Interpersonal level (parent/peer) | 27 | (57) |
| Environmental level (school/home/community) | 30 | (64) |
| **Intervention strategy (multiple possible)** | | |
| Education | 32 | (68) |
| Restructuring environment | 21 | (45) |
| Social marketing | 13 | (28) |
| Computer/online program | 4 | (9) |
| Peer influence | 3 | (6) |
| **Measurement instrument of water consumption** | | |
| Food Frequency Questionnaire | 26 | (55) |
| 24-hour recall | 11 | (23) |
| Prospective dietary records | 4 | (9) |
| Observation | 6 | (13) |
| **Outcome water consumption** | | |
| Volume consumed | 14 | (30) |
| Glasses/servings consumed | 11 | (23) |
| Consumption occasions | 12 | (26) |
| Proportion children that consumed water | 10 | (21) |

[a]Total is 48, because one study was located in Mexico and USA; [b] For 3 studies, number of participants was not reported, only number of schools/programs was reported.

71, 75-78, 80-84), social marketing (13/47)(39, 44, 49, 61, 65, 67, 68, 71, 75, 76, 78, 80, 83), computer/online programs (4/47)(42, 44, 54, 72) and peer influence (3/47)(40, 42, 63).

The Food Frequency Questionnaire (FFQ) was the most commonly used assessment tool (26/47 studies)(36, 40, 43, 48, 50, 58-61, 63, 64, 67-69, 72, 74, 76, 77, 79-85, 87) to measure water consumption. The most common outcome measure was water consumption in volume (14/47 studies)(36, 37, 42, 48, 54, 61, 65, 66, 75, 77, 80, 83-85) such as millilitres, ounces, or cups.

## Risk of bias

Risk of bias assessment of RCTs is reported in Table S3 and risk of bias of other designs is reported in Table S4. Among the 24 RCTs, overall risk of bias was classified as high in 19/24 studies, low in 1/24 studies and unclear in 4/24 studies. On average among the 6 bias domains, 51% domains were classified as 'low bias', 26% as 'high bias' and 22% as 'unclear bias'. Among the studies with other designs, overall risk of bias was classified as serious in 21/23 studies and critical in 2/23 studies. On average, among the seven bias domains, 46% domains were classified as 'low or moderate bias', 33% as 'serious bias', 1% as 'critical bias' and 20% as 'unclear bias or not applicable'. A large source of risk of bias was measurement of outcome for both RCTs and other designs, due to reliance on one day 24-hour recall or FFQ; 18/24 RCTs used this and 20/23 of studies with other designs. Retrospective recall for self-reported or proxy-reported dietary intake is considered unreliable and repeated recalls and diaries are the most appropriate report—based methods to assess fluid intake in children and adolescents (88). Risk of bias due to incomplete outcome/missing data was high in only 6/24 RCTs and unclear in 3/24 RCTs, but for studies with other designs, this was unclear in 5/23 studies, serious in 8/23 studies and critical in 1/23 studies. Another frequent source of risk of bias for RCTs was not blinding of participants, personnel and outcome assessors, which was high in 3/24 RCTs and unclear for 14/24 RCTs because it was not reported. However, blinding is not feasible for interventions that use education or restructuring of the environment. For studies with other designs, a large source of risk of bias was due to possible confounding, which was serious for 13/23 studies that did not correct for confounding variables such as sex, age and baseline water consumption. Risk of bias in the other bias domains- random sequence generation, allocation concealment and selective outcome reporting for RCTs and selection of participants, classification of/ departures from interventions and selection of the reported result for other design- was lower than that in the aforementioned domains.

## Effectiveness of interventions on water consumption in children

Of the 47 studies included in our review, 24 reported statistically significant effects on children's water consumption (Table S2). Among studies that focused on diet and other lifestyle factors, 9/23 (39%) studies reported significant effects; among studies that focused on diet only, 6/11 (55%) studies reported significant effects; and among studies that focused on beverage consumption only, 9/13 (69%) studies reported significant effects. Among the interventions based at school, 16/28 (57%) reported significant effects; among the interventions in nonschool settings, 7/11 (64%) reported significant effects; and among interventions based at both school and nonschool settings, 1/8 (13%) reported significant effects. Among interventions that only targeted the individual socioecological level, 2/7 (29%) reported significant effects; among interventions that

targeted the interpersonal level combined with the individual level, 6/10 (60%) reported significant effects; among interventions that targeted the environmental level only or combined with one other level, 10/17 (59%) reported significant effects; and among interventions that targeted all levels, 6/13 (46%) reported significant effects. Among the RCTs, 9/24 (38%) studies reported significant effects between intervention and control group; and among other designs, 15/23 (65%) studies reported significant effects.

## Meta-analysis

### Overall effects

Results from the 24 studies included in the meta-analysis show that the interventions increased water consumption among children (Figure 2). The mean difference between control and intervention groups was 29 mL/d (CI= 13; 46 mL/d, N=32,206, Z=3.36, P<.001). The studies were significantly heterogeneous ($\chi^2$=67.47, df=23, P < .001, $I^2$=66%).

### Effect by focus of intervention

There were 16 interventions that focused on diet and other lifestyle factors and eight interventions that focused on diet only (of which six focused only on beverage consumption). Interventions that focused on diet and other lifestyle factors had overall smaller

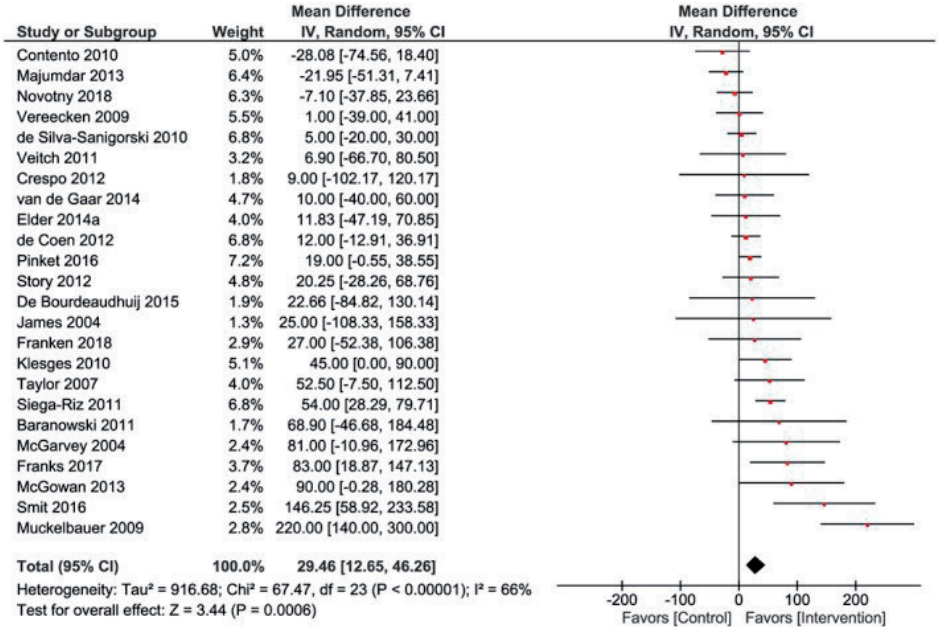


**Figure 2.** Random-effects meta-analysis of the mean difference in children's water consumption (in millilitre per day) between intervention and control groups (n = 24).

mean differences between intervention and control groups (Table 2 & Fig. S1: MD=15 mL/d, CI=1; 29 mL/d, P=.03, $I^2$=44%) than had studies that focused only on diet or beverages (MD=73 mL/d, CI=20; 126 mL/d, P=.007; $I^2$=78%). This difference was statistically significant (P=.04).

**Table 2.** Subgroup analyses using random-effects models of the mean difference in children's water consumption between intervention and control groups (n=24).

| | Number of studies | Estimate (ml/day) | 95% CI (ml/day) | P-value estimate | Heterogeneity (I2) | P-value sub-group difference(s) |
|---|---|---|---|---|---|---|
| **Focus of intervention** | | | | | | 0.04 |
| Diet | 8 | 72.80 | 19.51; 126.09 | 0.007 | 78% | |
| Diet and other lifestyle factors | 16 | 15.36 | 1.40; 29.32 | 0.03 | 44% | |
| **Intervention strategy** | | | | | | 0.33 |
| Education only | 8 | 16.59 | -14.23; 47.42 | 0.29 | 54% | |
| Other strategies with/ without education | 16 | 34.70 | 14.62; 54.77 | <0.001 | 69% | |
| **Intervention setting** | | | | | | 0.002 |
| School | 13 | 32.99 | 6.03; 59.95 | 0.02 | 77% | |
| Nonschool | 5 | 64.70 | 33.67; 95.74 | <0.001 | 0% | |
| School and nonschool | 6 | 5.48 | -8.89; 19.86 | 0.45 | 0% | |
| **Socioecological level targeted** | | | | | | 0.004 |
| Individual level only | 4 | -18.92 | -42.90; 5.06 | 0.12 | 0% | |
| Interpersonal- with/ without individual level | 6 | 54.87 | 13.85; 95.88 | 0.009 | 56% | |
| Environmental- with/ without one other level | 7 | 41.77 | 4.47; 79.08 | 0.03 | 83% | |
| All levels | 7 | 18.65 | 4.95; 32.35 | 0.008 | 0% | |
| **Mean age of children** | | | | | | 0.16 |
| 2-5 years | 10 | 15.56 | 1.49; 29.63 | 0.03 | 27% | |
| 6-12 years | 14 | 40.12 | 9.26; 70.99 | 0.01 | 75% | |
| **Study design** | | | | | | 0.19 |
| Randomized controlled trial | 17 | 21.36 | 6.34; 36.38 | 0.005 | 42% | |
| Other controlled design | 7 | 56.81 | 6.46; 107.15 | 0.03 | 85% | |

Abbreviations: CI=Confidence Interval; ml=millilitre

### Effect by intervention strategy

Eight interventions that only used education as an intervention strategy had an overall smaller mean difference between intervention and control groups (Table 2 & Fig. S2: MD=17 mL/d, CI=-14; 47 mL/d, P=.29, $I^2$=54%) than had 16 interventions that used other strategies such as restructuring the environment or social marketing with/without education (MD=35 mL/d, CI=15; 55 mL/d, P<.001, $I^2$=69%). This difference was not statistically significant (P=.33).

### Effect by intervention setting

There were 13 interventions that were in a school setting, five interventions that were based in a nonschool setting (community or home), and six interventions that were based in both a school and nonschool setting. Interventions based in both a school and nonschool setting had the smallest mean difference between intervention and control groups (Table 2 & Fig. S3: MD=5 mL/d, CI=-9; 20 mL/d, P=.96, $I^2$=0%), followed by interventions that were based in a school setting (MD=33 mL/d, CI=6; 60 mL/d, P=.02; $I^2$=77%) and interventions that were based in a nonschool setting (MD=65 mL/d, CI=34; 96 mL/d, P<.001; $I^2$=0%). Differences between these three groups were statistically significant (P=.002).

### Effect by socioecological level targeted

Four interventions that only targeted the individual level had the lowest and negative mean difference between intervention and control groups (Table 2 & Fig. S4: MD=-19 mL/d, CI=-43; 5 mL/d, P=.12, $I^2$=0%), followed by seven interventions that targeted all levels (MD=19 mL/d, CI=5; 32 mL/d, P=.008, $I^2$=0%), seven interventions that targeted the environment with/without one other level (MD=42 mL/d, CI=4; 79 mL/d, P=.03, $I^2$=83%), and six interventions that targeted the interpersonal level with/without the individual level (MD=55 m:L/d, CI=14; 96 mL/d, P=.009, $I^2$=56%). Differences between these four groups were statistically significant (P=.004).

### Effect by mean age of children

Ten interventions that targeted children with a mean age at baseline of between 2 to 5 years had an overall smaller mean difference between intervention and control group (Table 2 & Fig. S5: MD=16 mL/d, CI=1; 30 mL/d, P=.03, $I^2$=27%) than had 14 studies that targeted children with a mean age at baseline of between 6 to 12 years (MD=40 mL/d, CI=9; 71 ml/d, P<.001; $I^2$=75%). This difference was not statistically significant (P=.16).

### Sensitivity analyses

The 17 RCTs had overall smaller mean difference between intervention and control groups (Table 2 & Fig. S6: MD=21 mL/d, CI=6.; 36 mL/d, P=.005, $I^2$=42%) than had seven

controlled studies with other designs (MD=57 mL/d, CI=6; 107 mL/d, P=.03; $I^2$=85%). This difference was not statistically significant (P=.19). The overall analysis was repeated with 23 studies, which reported or for which we could calculate mean water consumption in control and intervention groups at follow-up (Fig. S7). Mean difference between control and intervention groups was larger than the overall effect (MD=37 mL/d, CI= 11; 64 mL/d, N=31,266, Z=2.76, P=.006, $I^2$=86%). Funnel plot inspection indicated that there were fewer small studies that had a negative effect than what would be expected (Fig. S8). For two studies (9, 40), the mean difference between intervention and control groups was larger (outside of the 95% confidence interval) compared with the other studies (Fig. S8). When excluding these two studies, the average mean difference between intervention and control groups and heterogeneity of the 22 remaining studies were smaller than the overall effect (MD=18 mL/d, CI=5; 31 mL/d, N=15,966, Z=2.81, P=.005, $I^2$=39%).

## DISCUSSION

In this systematic review and meta-analysis, we investigated the effect of interventions to promote water consumption among children. A total of 47 studies were included that used a large variety of intervention strategies that focused on promoting water consumption, often combined with other diet and/or lifestyle factors. Results from our meta-analysis indicate that these interventions can lead to a small improvement in water consumption among children. Interventions that focused on diet alone had greater effects on water consumption than had interventions that also included other lifestyle factors. Significant subgroup differences were also found by study setting and socioecological level targeted but not by children's age group, intervention strategy, or study design.

The effect on children's water consumption across the studies included in our review may appear small. However, the size of the effect is also dependent on children's mean water consumption, which varied considerably between the included studies. Our findings confirm evidence from earlier reviews on water consumption in children that found positive but small effects(24, 34). Vargas-Garcia et al found an average effect of around two oz (60 mL) per day among children older than 3 years(24). Cradock et al found effects between 0.5 and 3.5 oz (15-105 mL) per day for children aged 0 to 5 years(34). The average overall effect in our review was around 30 mL/d but varied from -28 to 220 mL between studies. Specific interventions may therefore be more effective than others as the lifestyle interventions included in our review showed a wide variation in duration, setting, the lifestyle behaviours focused on, the intervention strategies used to promote water consumption, and the persons or environment targeted by the intervention. Two

studies, an RCT by Smit et al that used a peer-influence intervention strategy and a large non-RCT by Muckelbauer et al that installed water fountains at schools had a larger effect (220 and 146 mL, respectively) compared with the effect of most other studies included in our review. While these interventions were different in many aspects, the interventions both focused specifically on promoting water consumption and not on decreasing SSB intake or changing other factors.

Many of the interventions included in this review focused on modifying a wide range of lifestyle behaviours among children. These interventions, sometimes called 'combined' or 'holistic' lifestyle interventions, have been found to be particularly effective in reducing weight among both general populations of children and children with obesity(23, 32). We, however, found that interventions that specifically focused on diet or beverage consumption on average had a larger effect on water consumption among children than had these combined lifestyle interventions. A reason for this could be that within these broader interventions, the message to drink water receives less attention or gets lost within a multitude of other themes such as physical activity and active play. The design of the intervention strategy itself influences the uptake of messages related to water intake. A combined lifestyle RCT by Contento et al did not have an effect on water consumption, but did decrease SSB intake(48). This finding illustrates that children may not necessarily replace SSBs by water. Contento et al report that with regard to the intervention, more time was spent on behaviours related to energy balance and diabetes and that the activities children engaged in were more 'memorable' than for behaviours related to water(48). When wanting to increase water and decrease SSB consumption, messages that promote water consumption may need to be prioritized alongside messages that limit SSB consumption. Additionally, intervention fidelity might also be lower for combined interventions due to having to divide time and resources over multiple interventions goals(89). Intervention goals that are easier to implement might then be prioritized over goals that are more difficult to implement(61, 80). Siega Riz et al noted that replacing SSBs by water in vending machines was not possible in all schools involved in their combined lifestyle intervention(80). De Coen et al found that most schools did not meet their suggested snacks and beverage policy guidelines, which included the installation of water fountains(61).Of note is that many countries promote both water and cow's milk as healthy beverages, and these may be competing for messaging space. Especially in settings where malnutrition is a major public health concern, (fortified) cow's milk can contribute important nutrients to a child's diet(90, 91). Although guidelines mainly recommend including skim or low-fat milk as part of children's diet(4, 6), recent observational evidence points towards a negative association between milk fat percentage and children's body mass index (BMI)(92, 93).More research is therefore necessary

on the effectiveness of interventions that promote water and/or milk consumption on improving weight and other health-related outcomes in children.

Although the majority of interventions were based in school settings, interventions in only nonschool settings on average achieved the greatest effect on children's water consumption than did those either in school or in both school and nonschool settings. It might be that there is more room for improvement in water consumption in nonschool settings. Some studies have found that children are more likely to consume SSBs at nonschool settings such as home(94, 95) or recreation venues(96) and on weekends(97, 98). Similarly, Vargas-Garcia et al found that lifestyle interventions in home settings achieved greater reductions in children's SSB consumption than those in school settings(24). The greater involvement of parents in home-based interventions compared with school interventions was suggested to be an important factor in the greater success of these interventions(24). Indeed, all nonschool based interventions in our meta-analysis where either based at home or involved parents directly in a community setting. Targeting only the child may not be the best intervention target, as we found that interventions that only targeted the child had a smaller effect than had interventions that also or only targeted parents, peers, and/or the environment. For future interventions, this emphasizes the importance of viewing childhood consumption behaviours within a socioecological framework, as children may be particularly receptive to their social and structural environments. In addition, interventions for young children may be more effective if the caregiver is targeted rather than the child, since the caregiver selects and provides most meals and drinks. So far, research has mainly focused on the association between child-related factors and water consumption and especially environmental factors have been understudied(30). Environmental interventions such as choice architecture interventions may be a promising approach to promote healthy dietary behaviours.(99, 100) Which specific parental- and environmental factors need to be targeted in order to improve water consumption among children and which specific components of interventions are most effective in doing so needs to be studied in more detail.

## Strengths and limitations

To the best of our knowledge, this was the first systematic review and meta-analysis that focused solely on the effectiveness of interventions in promoting water consumption among children aged 2 to 12 years. The literature search was performed in seven databases, and a rigorous procedure was followed for the inclusion of studies in our review (101). However, our review also has some limitations that must be acknowledged. We included RCTs, non-RCTs and other quasi-experimental designs in our systematic review and meta-analysis. Non-RCTs and other quasi-experimental designs are considered to

provide lower quality evidence and more often show significant results than are RCTs when there are none. We found a lower effect in RCTs compared with other controlled designs in our meta-analysis, although this difference was not significant. Heterogeneity was moderate to high across the studies included in our review and subgroup analyses were only partly able to explain this variation. Other differences between studies that were not explored may have explained this variation. Whether or not interventions are theory based may be an important factor in the effectiveness of interventions; however, only two studies included in our meta-analysis were not theory based. Further, Cochrane advises to have at least 10 studies in each subgroup(41), which was not the case for some subgroup analyses in our review. However, findings from subgroup analyses in the meta-analysis were confirmed in the qualitative subgroup analyses performed with a larger number of studies, which strengthened our findings. Risk of bias was high in most studies, which was, to a large part, due to measurement of outcomes. Retrospective report, which was most commonly used in the studies included in this review, is considered to be imprecise due to poor recall and (parents of) children with low levels of water consumption reporting higher amounts than actual amounts consumed(105, 102-104). For our meta-analysis, we estimated water consumption in millilitres per day for studies that did not report water consumption in volume per day by using a serving size of 225 mL. This may appear more imprecise compared with volume of water consumed per day, however it is uncertain to what level of precision children and parents can estimate their water consumption(105).For younger children aged 2 to 5 years, a serving size of 225 mL may be relatively large; however, because national standardized serving sizes are between 200 and 250 mL, other studies have used similar serving sizes in this age group(24, 49). Changing serving size to 150 mL for studies with young children that did not report serving size(73, 74) did not change our overall estimate. Finally, we did not include studies published in non-English languages and studies that were not published in a peer-reviewed journal, this may impact on the generalizability of our results and may have introduced publication bias(106).

## Conclusions

In conclusion, our systematic review and meta-analysis indicate that interventions can on average lead to a small increase in daily water consumption among children. Dietary interventions and interventions that focus on beverage intake specifically appear to have greater effects on improving children's water consumption than have interventions that focus on both diet and other lifestyle factors. Effects also appeared to vary by study setting and socioecological level targeted. However, more research is needed to further understand the specific intervention elements that have the greatest impact on the water consumption of children. Future research is also needed to determine

the effectiveness of these interventions on improving weight and other health-related outcomes in children.

## SUPPLEMENTAL MATERIAL

### Supplement File 1. Search strategies used

| | | |
|---|---|---|
| **embase.com** | 10016 | 9854 |
| **Medline Ovid** | 9281 | 3753 |
| **Web of science** | 9608 | 3857 |
| **PsycINFO Ovid** | 1501 | 328 |
| **Cochrane CENTRAL** | 769 | 210 |
| **CINAHL EBSCOhost** | 4537 | 1210 |
| **Google scholar (top relevant references)** | 200 | 134 |
| **Total** | 35912 | 19346 |

*New references found: 1673*

**embase.com**

('fluid intake'/exp OR 'beverage'/de OR 'carbonated beverage'/de OR 'carbonated water'/de OR 'drinking water'/de OR 'mineral water'/de OR 'soft drink'/de OR 'sports drink'/de OR 'sweetened beverage'/exp OR 'fruit juice'/exp OR 'fruit and vegetable juice'/de OR tea/de OR 'energy drink'/de OR (((water OR tapwater OR fluid* OR beverage* OR liquid*) NEXT/1 (drinking)) OR ((water OR fluid* OR beverage* OR liquid* OR juice OR drink* OR tea) NEAR/6 (intake* OR consum*)) OR ((carbonat* OR fizzy OR soda OR seltzer OR co2 OR co-2 OR bubble OR sugar* OR nonsugar* OR sweet* OR nonalcohol* OR non-alcohol* OR energy OR soft OR fruit OR sucralose* OR neotame* OR acesulfame* OR saccharin* OR sport*) NEAR/3 (beverage* OR water OR drink*)) OR 'fruit juice*' OR soda OR lemonade OR (bottle* NEAR/3 water)):ab,ti) AND ('child'/de OR 'preschool child'/de OR 'school child'/de or 'primary school'/de OR 'child behavior'/de OR 'child health'/de OR 'child nutrition'/de OR childhood/de OR 'childhood obesity'/de OR (child* OR toddler* OR preschool* OR preschool* OR schoolchild* OR primary-school* OR elementary-school* OR kindergar*):ab,ti) AND ('risk factor'/exp OR 'social aspects and related phenomena'/exp OR 'social determinants of health'/exp OR 'parent'/exp OR 'lifestyle'/exp OR 'behavior change'/exp OR 'environmental factor'/exp OR 'parental behavior'/exp OR 'child parent relation'/exp OR 'health care policy'/de OR government/de OR 'family life'/de OR advertising/de OR 'television viewing'/de OR 'eating habit'/de OR 'feeding behavior'/de OR 'parental attitude'/exp OR demography/exp OR tax/de OR prevention/exp OR 'health promotion'/exp OR 'health education'/exp OR 'community program'/exp OR 'mass medium'/exp OR 'review'/exp OR 'intervention study'/de OR 'evaluation study'/exp OR 'clinical trial'/exp OR 'caregiver'/de OR (determinant* OR influen* OR factor* OR social OR socio* OR parent* OR mother* OR father* OR maternal* OR paternal* OR lifestyle* OR life-style* OR ((behav* OR habit* OR pattern* OR practic*) NEAR/3 (change* OR diet* OR

feeding OR food OR snack* OR intervent* OR health* OR unhealth* OR eating)) OR (environment* NEAR/3 (factor* OR condition* OR home OR school)) OR adverti* OR policy OR policies OR government* OR income OR poverty OR neighbourhood OR neighborhood OR communit* OR sedentar* OR tax OR taxes OR television OR (screen NEAR/3 (view* OR time)) OR Prevent* OR reduc* OR increas* OR promot* OR education OR curriculum OR program* OR polic* OR media OR television OR campaign* OR review* OR intervention* OR initiative* OR strateg* OR evaluation OR trial* OR effect* OR impact* OR ((parent OR role) NEAR/3 model*) OR caregiver* OR ((access OR availab* OR quality OR supply) NEAR/3 (water OR drinkwater))):ab,ti) NOT ([animals]/lim NOT [humans]/lim) NOT ('alcohol consumption'/exp OR ((alcohol OR binge) NEAR/3 (drinking OR consum*)):ab,ti) NOT ([Conference Abstract]/lim OR [Letter]/lim OR [Note]/lim OR [Editorial]/lim) AND [english]/lim

**Medline Ovid**

(Beverages/ OR exp Carbonated Beverages/ OR exp Drinking Water/ OR exp Drinking/ OR exp Mineral Waters/ OR Fruit and Vegetable Juices/ OR Tea/ OR exp Energy Drinks/ OR (((water OR tapwater OR fluid* OR beverage* OR liquid*) ADJ (drinking)) OR ((water OR fluid* OR beverage* OR liquid* OR juice OR drink* OR tea) ADJ6 (intake* OR consum*)) OR ((carbonat* OR fizzy OR soda OR seltzer OR co2 OR co-2 OR bubble OR sugar* OR nonsugar* OR sweet* OR nonalcohol* OR non-alcohol* OR energy OR soft OR fruit OR sucralose* OR neotame* OR acesulfame* OR saccharin* OR sport*) ADJ3 (beverage* OR water OR drink*)) OR fruit juice* OR soda OR lemonade OR (bottle* ADJ3 water)).ab,ti.) AND (exp Child/ OR exp Infant/ OR exp Adolescent/ OR exp "Child Behavior"/ OR exp "Parent Child Relations"/ OR exp "Pediatrics"/ OR "Child Nutrition Sciences"/ OR "Infant nutritional physiological phenomena"/ OR "Child Rearing"/ OR "Child Psychology"/ OR (child* OR toddler* OR pre-school* OR preschool* OR schoolchild* OR primary-school* OR kindergar*).ab,ti.) AND (exp Risk Factors/ OR exp Sociological Factors/ OR exp Social Determinants of Health/ OR exp Parents/ OR exp Life Style/ OR exp Parent-Child Relations/ OR exp Health Policy/ OR exp Government/ OR exp Family Relations/ OR Advertising as Topic/ OR Television/ OR exp Feeding Behavior/ OR exp Demography/ OR Taxes/ OR exp preventive medicine/ OR exp Health Promotion/ OR exp Health Education/ OR Review/ OR Review Literature as Topic/ OR Evaluation Studies/ OR Evaluation Studies as Topic/ OR exp Clinical Trial/ OR Clinical Trials as Topic/ OR Caregivers/ OR (determinant* OR influen* OR factor* OR social OR socio* OR parent* OR mother* OR father* OR maternal* OR paternal* OR lifestyle* OR life-style* OR ((behav* OR habit* OR pattern* OR practic*) ADJ3 (change* OR diet* OR feeding OR food OR snack* OR intervent* OR health* OR unhealth* OR eating)) OR (environment* ADJ3 (factor* OR condition* OR home OR school)) OR adverti* OR policy OR policies OR government* OR income OR poverty OR neighbourhood OR neighborhood OR communit* OR sedentar* OR tax OR

taxes OR television OR (screen ADJ3 (view* OR time)) OR Prevent* OR reduc* OR increas* OR promot* OR education OR curriculum OR program* OR polic* OR media OR television OR campaign* OR review* OR intervention* OR initiative* OR strateg* OR evaluation OR trial* OR effect* OR impact* OR ((parent OR role) ADJ3 model*) OR caregiver* OR ((access OR availab* OR quality OR supply) ADJ3 (water OR drinkwater))).ab,ti.) NOT (exp animals/ NOT humans/) NOT (alcohol consumption/ OR ((alcohol OR binge) ADJ3 (drinking OR consum*)).ab,ti.) NOT (letter* OR news OR comment* OR editorial* OR congres* OR abstract* OR book* OR chapter* OR dissertation abstract*).pt. AND english.la.

**PsycINFO Ovid**

(fluid intake/ OR "Beverages (Nonalcoholic)"/ OR exp Water Intake/ OR (((water OR tapwater OR fluid* OR beverage* OR liquid*) ADJ (drinking)) OR ((water OR fluid* OR beverage* OR liquid* OR juice OR drink* OR tea) ADJ6 (intake* OR consum*)) OR ((carbonat* OR fizzy OR soda OR seltzer OR co2 OR co-2 OR bubble OR sugar* OR nonsugar* OR sweet* OR nonalcohol* OR non-alcohol* OR energy OR soft OR fruit OR sucralose* OR neotame* OR acesulfame* OR saccharin* OR sport*) ADJ3 (beverage* OR water OR drink*)) OR fruit juice* OR soda OR lemonade OR (bottle* ADJ3 water)).ab,ti.) AND (100.ag. OR 200.ag. OR "Child Psychology"/ OR (child* OR toddler* OR pre-school* OR preschool* OR schoolchild* OR primary-school* OR kindergar*).ab,ti.) AND (exp Risk Factors/ OR exp Sociocultural Factors/ OR exp Socioeconomic Status/ OR exp Parents/ OR exp LifeStyle/ OR exp Parent Child Relations/ OR exp Health Care Policy/ OR exp Government/ OR exp Family Relations/ OR Advertising/ OR Television/ OR Television viewing/ OR Mass media/ OR exp Food intake/ OR exp Eating behavior/ OR exp Demographic Characteristics/ OR Taxation/ OR exp preventive medicine/ OR prevention/ OR exp Health Promotion/ OR exp Health Education/ OR "literature Review"/ OR Evaluation/ OR Caregivers/ OR (determinant* OR influen* OR factor* OR social OR socio* OR parent* OR mother* OR father* OR maternal* OR paternal* OR lifestyle* OR life-style* OR ((behav* OR habit* OR pattern* OR practic*) ADJ3 (change* OR diet* OR feeding OR food OR snack* OR intervent* OR health* OR unhealth* OR eating)) OR (environment* ADJ3 (factor* OR condition* OR home OR school)) OR adverti* OR policy OR policies OR government* OR income OR poverty OR neighbourhood OR neighborhood OR communit* OR sedentar* OR tax OR taxes OR television OR (screen ADJ3 (view* OR time)) OR Prevent* OR reduc* OR increas* OR promot* OR education OR curriculum OR program* OR polic* OR media OR television OR campaign* OR review* OR intervention* OR initiative* OR strateg* OR evaluation OR trial* OR effect* OR impact* OR ((parent OR role) ADJ3 model*) OR caregiver* OR ((access OR availab* OR quality OR supply) ADJ3 (water OR drinkwater))).ab,ti.) NOT (exp animals/ NOT humans/) NOT (Alcohol Drinking Patterns/ OR ((alcohol OR binge) ADJ3 (drinking OR consum*)).ab,ti.) NOT (letter* OR news OR comment* OR editorial* OR congres* OR abstract* OR book* OR chapter* OR dissertation abstract*).pt. AND english.la.

**CINAHL EBSCOhost**

(MH Beverages OR MH Carbonated Beverages+ OR MH Water OR MH Fruit Juices+ OR MH Tea OR MH Energy Drinks+ OR MH Sports Drinks+ OR (TI ((water OR tapwater OR fluid* OR beverage* OR liquid*) N1 (drinking)) OR ((water OR fluid* OR beverage* OR liquid* OR juice OR drink* OR tea) N5 (intake* OR consum*)) OR ((carbonat* OR fizzy OR soda OR seltzer OR co2 OR co-2 OR bubble OR sugar* OR nonsugar* OR sweet* OR nonalcohol* OR non-alcohol* OR energy OR soft OR fruit OR sucralose* OR neotame* OR acesulfame* OR saccharin* OR sport*) N2 (beverage* OR water OR drink*)) OR fruit juice* OR soda OR lemonade OR (bottle* N2 water)) OR AB (((water OR tapwater OR fluid* OR beverage* OR liquid*) N1 (drinking)) OR ((water OR fluid* OR beverage* OR liquid* OR juice OR drink* OR tea) N5 (intake* OR consum*)) OR ((carbonat* OR fizzy OR soda OR seltzer OR co2 OR co-2 OR bubble OR sugar* OR nonsugar* OR sweet* OR nonalcohol* OR non-alcohol* OR energy OR soft OR fruit OR sucralose* OR neotame* OR acesulfame* OR saccharin* OR sport*) N2 (beverage* OR water OR drink*)) OR fruit juice* OR soda OR lemonade OR (bottle* N2 water))) AND (MH Child+ OR MH Infant+ OR MH Adolescence+ OR MH "Child Behavior+" OR MH "Parent Child Relations+" OR MH "Pediatrics+" OR MH "Child Nutritional Physiology+" OR MH "Child Rearing+" OR MH "Child Psychology" OR TI (child* OR toddler* OR pre-school* OR preschool* OR schoolchild* OR primary-school* OR kindergar*) OR AB (child* OR toddler* OR pre-school* OR preschool* OR schoolchild* OR primary-school* OR kindergar*)) AND (MH Risk Factors+ OR MH Social Determinants of Health+ OR MH Parents+ OR MH Life Style+ OR MH Parent-Child Relations+ OR MH Health Policy+ OR MH Government+ OR MH Family Relations+ OR MH Advertising OR MH Television OR MH Eating Behavior+ OR MH Demography+ OR MH Taxes OR MH Preventive Health Care+ OR MH Health Promotion+ OR MH Health Education+ OR MH Evaluation Research OR MH Caregivers OR TI (determinant* OR influen* OR factor* OR social OR socio* OR parent* OR mother* OR father* OR maternal* OR paternal* OR lifestyle* OR life-style* OR ((behav* OR habit* OR pattern* OR practic*) N2 (change* OR diet* OR feeding OR food OR snack* OR intervent* OR health* OR unhealth* OR eating)) OR (environment* N2 (factor* OR condition* OR home OR school)) OR adverti* OR policy OR policies OR government* OR income OR poverty OR neighbourhood OR neighborhood OR communit* OR sedentar* OR tax OR taxes OR television OR (screen N2 (view* OR time)) OR Prevent* OR reduc* OR increas* OR promot* OR education OR curriculum OR program* OR polic* OR media OR television OR campaign* OR review* OR intervention* OR initiative* OR strateg* OR evaluation OR trial* OR effect* OR impact* OR ((parent OR role) N2 model*) OR caregiver* OR ((access OR availab* OR quality OR supply) N2 (water OR drinkwater))) OR AB (determinant* OR influen* OR factor* OR social OR socio* OR parent* OR mother* OR father* OR maternal* OR paternal* OR lifestyle* OR life-style* OR ((behav* OR habit* OR pattern* OR practic*) N2 (change* OR diet* OR feeding OR food OR snack* OR intervent* OR health* OR unhealth* OR eating)) OR (environment* N2 (factor* OR condition*

OR home OR school)) OR adverti* OR policy OR policies OR government* OR income OR poverty OR neighbourhood OR neighborhood OR communit* OR sedentar* OR tax OR taxes OR television OR (screen N2 (view* OR time)) OR Prevent* OR reduc* OR increas* OR promot* OR education OR curriculum OR program* OR polic* OR media OR television OR campaign* OR review* OR intervention* OR initiative* OR strateg* OR evaluation OR trial* OR effect* OR impact* OR ((parent OR role) N2 model*) OR caregiver* OR ((access OR availab* OR quality OR supply) N2 (water OR drinkwater)))) NOT (MH animals+ NOT MH humans) NOT (TI((alcohol OR binge) N2 (drinking OR consum*)) OR AB((alcohol OR binge) N2 (drinking OR consum*))) NOT PT (letter* OR news OR comment* OR editorial* OR congres* OR abstract* OR book* OR chapter* OR dissertation abstract*) AND LA (english)

**Cochrane CENTRAL**

((((water OR tapwater OR fluid* OR beverage* OR liquid*) NEXT/1 (drinking)) OR ((water OR fluid* OR beverage* OR liquid* OR juice OR drink* OR tea) NEAR/6 (intake* OR consum*)) OR ((carbonat* OR fizzy OR soda OR seltzer OR co2 OR "co 2" OR bubble OR sugar* OR nonsugar* OR sweet* OR nonalcohol* OR "non-alcohol*" OR energy OR soft OR fruit OR sucralose* OR neotame* OR acesulfame* OR saccharin* OR sport*) NEAR/3 (beverage* OR water OR drink*)) OR "fruit juice*" OR soda OR lemonade OR (bottle* NEAR/3 water)):ab,ti) AND ((child* OR toddler* OR (pre NEXT/1 school*) OR preschool* OR schoolchild* OR (primary NEXT/1 school*) OR (elementary NEXT/1 school*) OR kindergar*):ab,ti)

**Web of science**

TS=(((((water OR tapwater OR fluid* OR beverage* OR liquid*) NEAR/1 (drinking)) OR ((water OR fluid* OR beverage* OR liquid* OR juice OR drink* OR tea) NEAR/5 (intake* OR consum*)) OR ((carbonat* OR fizzy OR soda OR seltzer OR co2 OR co-2 OR bubble OR sugar* OR nonsugar* OR sweet* OR nonalcohol* OR non-alcohol* OR energy OR soft OR fruit OR sucralose* OR neotame* OR acesulfame* OR saccharin* OR sport*) NEAR/2 (beverage* OR water OR drink*)) OR "fruit juice*" OR soda OR lemonade OR (bottle* NEAR/2 water))) AND ((child* OR toddler* OR pre-school* OR preschool* OR schoolchild* OR primary-school* OR elementary-school* OR kindergar*)) AND ((determinant* OR influen* OR factor* OR social OR socio* OR parent* OR mother* OR father* OR maternal* OR paternal* OR lifestyle* OR life-style* OR ((behav* OR habit* OR pattern* OR practic*) NEAR/2 (change* OR diet* OR feeding OR food OR snack* OR intervent* OR health* OR unhealth* OR eating)) OR (environment* NEAR/2 (factor* OR condition* OR home OR school)) OR adverti* OR policy OR policies OR government* OR income OR poverty OR neighbourhood OR neighborhood OR communit* OR sedentar* OR tax OR taxes OR television OR (screen NEAR/2 (view* OR time)) OR Prevent* OR reduc* OR increas* OR

promot* OR education OR curriculum OR program* OR polic* OR media OR television OR campaign* OR review* OR intervention* OR initiative* OR strateg* OR evaluation OR trial* OR effect* OR impact* OR ((parent OR role) NEAR/2 model*) OR caregiver* OR ((access OR availab* OR quality OR supply) NEAR/2 (water OR drinkwater))))) AND DT=(article) AND LA=(english)

**Google scholar**

"water Drinking|consumption|intake" child|children determinants|determinant|influence|factors

**Table S1.** Data used/calculated from studies in meta-analysis.

| Author | Choices made (if applicable) | Calculations (if applicable) |
|---|---|---|
| Baranowski | Last time point | 1 ounce=29.57 ml |
| Contento | | Meals and in between meals added together, for SD1+2=$\sqrt{SD1^2+SD2^2}$. Multiplied by days and ml; 8 ounce glass=236.59 ml (in paper) |
| Crespo | Last time point<br>Fam+comm intervention | Glass=225 ml (self-estimated) |
| De Bourdeaudhuij | All countries together | Divided by 7 days and * 225 ml (self-estimated). SE recalculated to SD. Estimated same number of boys and girls in intervention and control group (unreported in paper) |
| de Silva-Sanigorski | | Glass/cup is 250 ml in paper |
| Elder | | 8-oz glass of water=236.59 ml (in paper) |
| Franken | | Glass=225 ml (self-estimated). N, Mean and SD at follow-up sent by author |
| Franks | Last time point (12 months post baseline), info+w+social group | SE=taken as SD, because very wide and in other paper Lahlou, 2015 reported as SD |
| James | | 250 ml glass (in paper) |
| Klesges | Last time point (2 year follow-up); | Serving=225 ml (self-estimated) |
| Majumdar | | Conservatively 5 ounce per point (4=20 ounce); 1.75 day per point (4=7 days). 1 ounce=29.57 ml |
| McGarvey | | 0.75 serving per point because mean is around 4 points (3 glasses) (1=0 times and 6=5 or more times). 1 occasion=225 ml (self-estimated) |
| McGowan | | 1 occasion=225 ml (self-estimated) |
| Muckelbauer | | Glass=200 ml (in paper) |
| Novotny | | Cups (in paper)=236.59 |
| Pinket | | SD and N sent by author |
| Siega-Riz | | Grams=ml |
| Smit | | Glass=225 ml (self-estimated) |
| Story | | 1 time=225 ml (self-estimated) |
| Taylor | | Divided by 3 days and * 225 ml (self-estimated) |
| van de Gaar | Child report | |
| Veitch | Last time point (20 months after start) | |
| Vereecken | Parent report (teacher report is negligible = 0.08 ml) | |

**Table S2.** Characteristics and effects of studies included in the review.

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Abi Haidar, 2011<br>Lebanon | Pretest-posttest<br>Jarrib Baleha 'try without it' | I= Education sessions at school for children offered by a graduate student.<br>Theory used=Health Belief Model<br>Focus=On beverage consumption<br>Freq=Four 50-min sessions<br>C=NA | L=2 weeks<br>FU=2 weeks | M=10.4 | Public school children (lower SES) | I=93<br>C=NA | FFQ<br><br>Cups/day | Yes | P=92%<br>R=85% |
| Baranowski, 2011<br>USA | RCT<br>Diab & nano | I= Two educational computer games, Diab or Nano, for children offered at home and played in sequence.<br>Theory used=Social cognitive, self-determination, and persuasion theories<br>Focus=On diet and lifestyle<br>Freq=9 sessions of 40 min game-play<br>C=Knowledge-based nutrition computer game offered at school and 8 sessions of game-based websites (each related to diet, PA and<br>obesity) | L=as long as desired<br>FU=two months (2 measure points) | R=10-12 | 50-95th percentile BMI, >50% ethnic minority communities, access high-speed internet | I=93<br>C=40 | 3 24-hr dietary recalls<br><br>Ounces/day | No | P=51%<br>R=93% |
| Bea, 2015<br>USA | Pretest-posttest<br>SNAP-Ed | I=Education teachers (TTT) administrators, staff and children at school offered by a professional nutrition educator.<br>Theory used=no theory reported<br>Focus=On diet<br>Freq=1-2 hr initial training, new material provided monthly<br>C=NA | L=varied between classrooms<br>FU=6 months | M=9.7 | Children who qualified for the Supplemental Nutrition Assistance Program-Education Program (SNAP Ed) | I=770<br>C=NA | 1 24-hr dietary recall<br><br>Times consuming water yesterday | No | P=72%<br>R=90% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Beets, 2014<br>USA | Pretest-posttest healthy lunchbox challenge | I=Incentive program for children, their parents and the staff at summer day camps with a competition to reach group-based healthy eating goals.<br>Theory used=Behavioral choice theory and goal-setting theory<br>Focus=On diet<br>Freq=4 days/week and 8 hr/day<br>C=NA | L=8 weeks<br>FU=3 years (3 measure points) | M=7.8<br>R=4-12 | 46% white non-Hispanic, 6-15% in poverty | I=~550<br>C=NA | 16-day observation<br><br>Proportion children reaching target/day | No | P=no info<br>R=no info |
| Beets, 2017<br>USA | Cluster RCT<br>STEPs-HE | I=Restructuring the afterschool environment by incorporating new routine practices, trainings and boosters sessions offered by research staff for site-leaders and staff, availability of healthy foods and development of guidelines for healthy menu and PA.<br>Theory used=Maslow's hierarchy of needs, nonspecific hypothesis in psychotherapy.<br>Focus=On diet<br>Freq=3 hr initial training, 4-6 booster sessions 20-30 min.<br>C=Delayed group, same intervention | L=2 years<br>FU=2 years | M=8 | Around a third African American | I=894 (10 afterschool programs)<br>C=760 (10 afterschool programs) | 4-day observation<br><br>Observing cups of water served during snack time/ day (Y/N) | Yes | P=100%<br>R=94% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Bender, 2013<br>USA | Pretest-posttest<br>Vida Saludable | I=Education as interactive group lessons (phase 2) at a health center and group community activities for mothers and children offered by trained a promotora ((community health advisor) tailored to Hispanic families.<br>Theory used: Social cognitive theory<br>Focus=On diet and lifestyle.<br>Freq=Phase 1: four times biweekly and phase 2: six times monthly<br>C=NA | L=9 months<br>FU=15 months | M=3.6 | low-income Mexican mothers with children included | I=33<br>C=NA | 1 24-hr dietary recall<br><br>Ounces/day | Yes | P=no info<br>R=70% |
| Brand, 2017<br>Germany | Pretest-Posttest | I=Multifaceted intervention to restructure the kindergarten environment by improvement of nutritional standards for kitchen staff, education, availability of healthy foods and water, policy changes, trying dishes with children, preparing mails, information for parents and availability of tap water (group A) or by a nutrition training for kitchen staff (group B).<br>Theory used=no theory reported<br>Focus=On diet<br>Freq= Group A: no info, group B 25 h training group C, no info<br>C=NA | L=5 years<br>FU=12 months | R=3-6 | 1 parent included for each child; more than 50% migrant background. | I=Group A: 171 group B: 80 group C: 123<br>C=NA | FFQ<br><br>Times/week | Yes | P=27-47%<br>R=75-86% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Canavera, 2009<br>USA | Pretest-posttest | I=Multifaceted intervention using education sessions for children at school by physical or health education teachers.<br>Theory used=Social cognitive theory<br>Focus=On diet and lifestyle.<br>Freq=4 modules in 12 sessions<br>C=NA | L=12 weeks<br>FU=12 weeks | R=10-12 | Mainly white children | I=122<br>C=NA | 1 24-hr dietary recall<br><br>Glasses/day | Yes | P=no info<br>R=no info |
| Contento, 2010<br>USA | Cluster RCT<br>Choice, Control, and Change | I=Education at school for children by science teachers about the interactions between biology, personal behavior and the environment and personal agency regarding healthy nutrition and activity, TTT for teachers and research staff helped to prepare lessons/give feedback.<br>Theory used=Social cognitive theory, self-determination theory, Questioning, Experimenting, Searching, Theorizing, and Applying to Life (QuESTA), guided goal-setting<br>Focus=On diet and lifestyle<br>Freq= 24 lessons of 45 min<br>C=Standard science curriculum of equal intensity and duration, receiving C3 the next term as a delayed intervention | L=8-18 weeks<br>FU=8-10 weeks | M=12 | Schools in underserved low-income neighborhoods | I=460<br>(5 schools)<br>C=437<br>(5 schools) | FFQ<br><br>8-ounce glasses per day & number days/week with meals and in between meals | No | P=99%<br>R=77% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Crespo, 2012<br>USA | Cluster RCT<br>Aventuras para Niños | I= Fam-only: Multifaceted family education intervention consisting of home-visits by trained promotoras and increasing active play and decreasing SSBs and television viewing.<br>Comm-only: Aimed to restructure the school/community environment for children and parents by availability of water, policy changes, healthy eating at school, and social marketing strategies.<br>Fam+comm: Both fam-only and comm-only.<br>Theory used: ecological systems theory, health belief model, social cognitive theory, structural model of health behavior.<br>Focus=On diet and lifestyle.<br>Freq=Promotoras received 22 hours of training in 11 sessions; 1 home-visit per month was to be scheduled.<br>C=No intervention | L=7 months (fam-intervention); 3 years (com-intervention)<br>FU=3 years (4 measure points) | M=5.9 | Largely Hispanic | I=Fam-only=96 (3 schools)<br>Fam+Com=83 (3 schools)<br>Com-only=128 (schools)<br>C=134 (4 schools) | FFQ<br><br>Glasses/day | No | P=97%<br>R=55% |
| de Bock, 2016<br>Germany | Cluster RCT | I=Activities and meal preparation at school by trained nutrition expert for children and parents.<br>Theory used=Social learning theory and exposure effect theory<br>Focus=On diet<br>Freq=15 2 hr sessions<br>C= Delayed, received the same intervention 6 months later than the intervention arm | L=6 months<br>F=12 months | M=4.3 | Third from immigration background | I=194 (10 schools)<br>C=183 (8 schools) | FFQ<br><br>Glasses/day | No | P=87%<br>R=81% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| De Bourdeaudhuij, 2015<br>Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Sweden & Spain | nRCT<br>IDEFICS | I=Multifaceted approach to restructure the school and community environment for children by availability of water, school food policy changes, social marketing changes, creation of community platforms with local public authorities and others, environmental changes in the community and education and activities offered by researchers, teachers and parents who received training.<br>Theory used=Socio-ecological model, intervention mapping<br>Focus=On diet and lifestyle.<br>Freq=10 modules<br><br>C=No intervention. | L=2 years<br>FU= 2 years | M=6 | General population | I=5727 (8 region counties)<br>C=5314 (8 region counties) | FFQ<br>Frequency/week | No | P=53%<br>R=68% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| de Coen, 2012 Belgium | Cluster RCT POP Project | I=Multifaceted intervention consisting of a website for parents, education and social marketing campaign for children at schools and community by teachers/other school staff who received training material and key community stakeholders who applied the social marketing campaign for children.<br>Theory used=Socio-ecological model, concept mapping, healthy school framework<br>Focus=On diet and lifestyle<br>Freq=4 meetings with teachers, 5 healthy weeks with weekly 1 hr lesson. Contact regional health boards at least twice/year<br>C=No intervention | L=2 years<br>FU=2 years<br>2 years (2 measure points) | M=5 | Low, middle and high SES communities | I=396 (3 communities)<br>C=298 (3 communities) | FFQ<br><br>Ml/day | No | P=63%<br>R=44% |
| De Silva-Sanigorski, 2010 Australia | Repeated cross-sectional controlled Romp & chomp | I=Multifaceted community-based intervention focused on social (parents) and structural environments of children consisting of a social marketing campaign and restructuring the preschool environment by availability of water and policy changes.<br>Theory used=Socio-ecological model<br>Focus=On diet and lifestyle<br>Freq=Various length and duration<br>C=Comparison communities drawn from local government areas | L=4 years<br>FU=control group only measured at follow-up and intervention 3 years (2 measure points) | 2 and 3.5 | General population | I=344<br>C=696 | 1 24-hr recall<br><br>Servings previous day | No | P=no info<br>R=NA |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Elder, 2014a<br>USA | Cluster RCT<br>MOVE/me Muevo | I= Multifaceted family education intervention at recreation centers consisting of workshops, a home-visit and phone consultation by trained health coach and restructuring environment of the recreation center in PA and healthy foods and beverages offered.<br>Theory used=Socio-ecological model<br>Focus=on diet and lifestyle.<br>Freq=4 1.5 h workshops, 1 h home visit, 2 10 min phone calls<br>C=take-home information and giveaways on non-obesity related topics | L =2 years<br>FU=2 years (3 measure points) | M=6.6 | Largely Hispanic | I=238 (15 recreation centers)<br>C=256 (15 recreation centers) | FFQ<br><br>servings/day | No | P=47%<br>R=91% |
| Elder, 2014b<br>USA, Mexico | nRCT<br>Agua para ninos (Water for Kids) | I= Multifaceted intervention consisting of positive reinforcement for water consumption at schools through teachers who were trained appraisals coupled with reduced access to restructuring the environment to reduce barriers to obtain water by distribution water and water bottles, pee meters installed, class activities and education for children at school and information for parents.<br>Theory used=Operant conditioning<br>Focus= On beverage consumption<br>Freq=1 hr teacher training, weekly lessons about water consumption (20-30 min)<br>C=No info | L=8-12 week<br>FU=6 or 10 weeks | Elementary school age | Mexican-American or Mexican background | I=2 schools<br>C=2 schools (no data individual children) | 10-day observation<br><br>Having water bottle on desk, water consumed at lunch | Yes | P=NA<br>R=NA |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Franken, 2018<br>Aruba | Cluster RCT<br>Share H2O | I=Identifying and training the most influential children as PIs to promote water consumption among children and asking the PIs to promote water consumption among children in their social networks at schools and handing out reusable water bottles.<br>Theory used=Social network principles<br>Focus=On beverage consumption<br>Freq=90 min training, received reusable water bottle, follow-up training in weeks two and five<br>C=No intervention | L= 8 weeks<br>FU=8 weeks | M=11.4 | General population | I=192 (2 schools)<br>C=185 (2 schools) | FFQ<br><br>Glasses/day | No | P=83%<br>R=96% |
| Franks, 2017<br>Poland | nRCT | I=group 1: Child and carer attended online coaching sessions from home; group 2: Child and carer attended online coaching sessions and restructuring the home environment by receiving water and half of both groups had access to online support.<br>Theory used=Installation theory<br>Focus=On beverage consumption.<br>Freq=2 sessions per week<br>C=No intervention | L=3 weeks<br>FU=12 months (6 measure points) | M=4.4 | Children who drank low quantities of water and high quantities of SSBs | I1a=64 I1b=72<br>I2a=65<br>I2b=72<br>C=61 | 7-day dietary record<br><br>Ml/day | Yes | P=94%<br>R=76% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Freedman, 2010<br>USA | Pretest-posttest<br>Snack Smart | I=Workshops taught by trained nutrition students for children and parents in public libraries.<br>Theory used=Social cognitive theory<br>Focus=On diet<br>Freq=5 workshops 6 hr total<br>C=NA | L=3 weeks<br>FU=3-4 months (3 measure points) | M=11.1 | Ethnically diverse | I=14<br>C=NA | FFQ<br><br>Frequency/day | No | P=25%<br>R=29% |
| Galvan, 2016<br>Mexico | Pretest-posttest | I=Social marketing promotion campaign at school to raise awareness on healthy eating and water drinking and make a daily plan of fruit and vegetables to bring to school and monitoring by teachers.<br>Theory used: Social marketing<br>Focus=On diet<br>Freq=30 min session<br>C=NA | L=3 months<br>FU=3 months (2 measure points) | R=6-12 | 56% private schools, rest public schools | I=226<br>C=NA | 1-day observation<br><br>Ml/day | Yes | P=no info<br>R=92% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Giles, 2012<br>USA | Delayed cluster-RCT<br>Out of School Nutrition and Physical Activity Initiative | I=Restructuring the environment by implementing menu changes and water-delivery systems at afterschool programs for children and training about goal setting, problem solving and implementing policies and communication strategies related to PA and nutrition for program directors and staff given by the research team.<br>Theory used=Social-ecological model and community-based participatory approach<br>Focus=0n beverage consumption.<br>Freq= three sessions 3 h<br>C=Delayed group, same intervention | L=6 months<br>FU=6 months | M=7.8 | Ethnically and economically diverse populations | I=10 programs<br>C=10 programs<br>(no data individual children) | 5-day observation<br><br>Ounces served/day | Yes | P=65%<br>R=80% |
| Gittelson, 2010<br>Hawaii | nRCT<br>Healthy Foods Hawaii | I=Restructuring the environment by increasing availability of healthy foods in stores and social marketing strategies including in-store posters, educational displays, stocking of healthy foods and shelf labels, cooking demonstrations and taste tests all aimed at parents.<br>Theory used=no theory reported<br>Focus=On diet<br>Freq=4 phases with 4-6 cooking demonstrations<br>C=No intervention | L=9-11 months<br>FU=9-11 months (2 measure points) | M=9.9 | Mother-child dyads from low-income multiethnic communities | I=64<br>C=53 | FFQ<br><br>Times/week | Yes | P=80%<br>R=no info |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Hornsby, 2017<br>USA | Pretest-posttest<br>Cavities Get Around | I=Multifaceted social marketing campaign aimed at children and parents focused at oral health and replacing SSBs by water which included advertising, social media, educational programs, text messaging, raise awareness, community engagement and education through promotores de salud (community health worker).<br>Theory used=Stages of change from the trans-theoretical Model<br>Focus=On beverage consumption<br>Freq=Various length and duration<br>C=NA | L=Various length and duration<br>FU=1.5 years (2 measure points) | 0.5-6 | Low-income parents selected who had child with appropriate age | I=600<br>C=NA | FFQ<br><br>Daily consumption (Y/N) | Yes | P=no info<br>R=no info |
| James, 2004<br>UK | Cluster RCT<br>CHOPPS | I=Education and activities for children in classroom about SSBs and water consumption delivered by researchers and assisted by teachers.<br>Theory used=no theory reported<br>Focus=On beverage consumption<br>Freq=4 sessions<br>C=No intervention | L=1 school year<br>FU=1 year (2 measure points) | M=8.7 | General population | I=295 (15 school classes)<br>C=279 (14 school classes) | 3-day dietary record<br><br>Glasses/3 days | No | P=71%<br>R=55% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Kaufman Shriqui, 2016, Israel | Cluster RCT | I=Education to mothers and children by trained dieticians, economists and PA teachers on healthy, affordable nutrition and PA teachers were trained to compliment children who had healthy lunch.<br>Theory used=social-ecological model<br>Focus=On diet and lifestyle.<br>Freq=10 weeks 45 min lectures/ week, weekly newsletter, 3 workshops<br>c=only PA lessons | L=3 months<br>FU=<br>6 months (3 measure points) | M=5.3 | Low SES | I=66 (4 schools)<br>C=165 (7 schools) | FFQ<br><br>Habitual water drinking (Y/N) | Yes | P=63%<br>R=97% |
| Klesges, 2010 USA | RCT<br>Memphis GEMS | I=Group behavioral counselling for children and parents by community center staff for girls and carers at community centers and educational field-trip.<br>Theory used=Social cognitive theory<br>Focus=On diet and lifestyle.<br>Freq=90 minute sessions weekly for 14 weeks and then monthly for 20 months<br>C=3-monthly sessions focused on self-esteem and social-efficacy | L=2 years<br>FU=2 years (3 measure points) | M=9.3 | African-American girls with BMI at or higher than 25th percentile for age | I=116<br>C=127 | 3 24-hr recall<br><br>servings/day | Yes | P=65%<br>R=80% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Laurence, 2007<br>Australia | Repeated cross-sectional<br>Fresh Kids | I=Multifaceted school intervention for children and staff coordinated by a community dietician based on social marketing and restructuring the environment which is incorporated in a municipal plan, nomination of lead teacher within each school, fruit and vegetable wholesalers and handing out seasonal free fruit, newsletters to parents, scheduling fruit breaks, development of school fruit/ water policies nutrition education curriculum provided to schools, and water bottles printed with student design logos.<br>Theory used=WHO Health Promoting Schools Framework<br>Focus=On diet<br>Freq= Children receive seasonal free fruit 2-4 times a year<br>C=NA | L=4 years<br>FU=3 years (4 measure points) | primary-school students | Schools are located within an urban multicultural municipality in which a high proportion of residents experience socioeconomic disadvantage | I=4 schools<br>C=NA<br><br>(no data individual children) | Lunchbox audit by teachers<br><br>Water in bottle on desk/in lunchbox | Yes | P=90%<br>R=81% (but in only 2/4 schools) |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Majumdar, 2013<br>USA | nRCT<br>Creature 101 game | I=Educational computer game for children at school on benefits of drinking water and healthy diet/ nutrition/PA, analyzing own eating and PA behaviors and set personal goals, reporting on own goal progress and lessons.<br>Theory used=Social cognitive and self-determination theories<br>Focus=On diet and lifestyle<br>Freq=9 sessions of 30 min<br>C=Month "Whyville" computer game about broad range of topics (excluding nutrition games) | L=1 month<br>FU=1 month (2 measure points) | M=11.3 | Public schools in low-income areas NYC | I=182 (4 schools)<br>C=159 (2 schools) | FFQ<br><br>Water consumption frequency | No | P=90%<br>R=67% |
| McGarvey, 2004<br>USA | nRCT<br>Fit WIC | I=Education groups and individual nutrition session with trained nutritionists for parents at WIC center; staff participated also in nutrition/PA training and were asked to model behaviors to parents.<br>Theory used=Social cognitive theory and self-efficacy theory<br>Focus=On diet and lifestyle<br>Freq=Educational groups every 2 months and individual session every 6 months<br>C=Standard WIC interventions (nutrition education every 2 months and individual session every 6 months), but lacked interventions content and supportive staff. | L=1 year<br>FU=1 year | M=3.1 | Ethnically diverse, low income. | I=121 (1 center)<br>C=65 (1 center) | 1 24-hr dietary recall<br><br>Times/day | Yes | P=85%<br>R=65% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| McGowan, 2013<br>UK | Cluster RCT<br>Healthy feeding habits | I=Education sessions by trained researchers to parents at home on offering fruit and vegetables, healthy snacks, and healthy drinks in which they received information about a.o. habit formation and healthy feeding.<br>Theory used=Habit model<br>Focus=On diet<br>Freq=4 visits of 1 h<br>C=No intervention | L= 8 weeks<br>FU=8 weeks (2 measure points) | M=3.2 | General population | I=51 (3 children's centers)<br>C=55 (3 children's centers) | FFQ<br><br>Occasions/day | Yes | P=60%<br>R=84% |
| Muckelbauer, 2009<br>Germany | nRCT | I=Multifaceted intervention for children and teachers consisting of restructuring the environment by installation water fountain(s) in schools, each child received a plastic water bottle and teachers were encouraged to organize filling of the water bottles each morning and teachers gave lessons to children on water needs.<br>Theory used=Theory of planned behavior, goal-setting strategy<br>Focus=On beverage consumption<br>Freq=4 lessons 45 min, booster session after 3 months, water bottle at beginning and after 5 months<br>C=No intervention | L= 10 months<br>FU=10 months (2 measure points) | M=8.3 | Children from deprived neighborhoods | I=1070 (17 schools)<br>C=917 (15 schools) | 1 24-hr dietary recall<br><br>Glasses/day | Yes | P=60%<br>R=84% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Novotny, 2018<br>USA Islands | Cluster RCT<br>Children's Healthy Living Program | I=Multifaceted intervention at preschool with 4 strategies: organizational policy change (preschool wellness policies), restructuring the environment (increasing access to healthy foods and environment for safe play), social marketing, and training (role models, parents, and teachers).<br>Theory=Social-ecological model, ANGELO framework<br>Focus=On diet and lifestyle.<br>Freq= Various length and duration<br>C=Delayed optimized intervention: activities that worked best were implemented after time period study | L= 2 years<br>FU=2 years (2 measure points) | M=5.4 | 64% indigenous children | I=1342 (9 communities)<br>C=1295 (9 communities) | 2-day dietary record<br><br>Cups/day | No | P=94%<br>R=71% |
| Patel, 2011<br>USA | nRCT | I=Multifaceted intervention at school consisting of restructuring the environment provision of tap water in school cafeteria, distribution of reusable water bottles to all school staff and students, implementation of school-wide social marketing promotional activities, education regarding the benefits of drinking water (posters, flyers, 1 education session to 30 parents).<br>Theory used=no theory reported<br>Focus=On beverage consumption<br>Freq=1 education session parents/ staff/children<br>C=No intervention | L=5 weeks<br>FU=2 months (3 measure points) | M=12.8 | Low income, ethnically diverse | I=377 (1 school)<br>C=440 (1 school) | 1 24hr recall<br><br>Drank water at school (Y/N) | Yes | P=78%<br>R=90% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Patel, 2016<br>USA | Cluster RCT | I=Multifaceted intervention based on restructuring the environment by installation (filtered) water dispensers or coolers, cups provided, social marketing promotional activities (posters, audio announcements, newsletters, prices) at school and provision of rewards at school.<br>Theory=Trans theoretical model, P's of social marketing, conceptual framework by Brennan et al. prevention childhood obesity.<br>Focus=On beverage consumption<br>Freq= No info<br>C=Only traditional water fountains | L= 6 weeks<br>FU=6 weeks (2 measure points) | M=12.7 | Low income, ethnically diverse | I=dispenser=203 (4 schools)<br>cooler=193 (4 schools)<br>C=199 (4 schools) | FFQ<br><br>Lunchtime water consumed (Y/N) | Yes | P=84%<br>R=98% |
| Pinket, 2016<br>Belgium, Bulgaria, Germany, Greece, Poland, Spain | Cluster RCT<br>Toybox | I=Multifaceted intervention at for children and staff at kindergarten consisting of trained teachers with material to provide education, classroom activities, restructuring the environment by installation of water stations, newsletters for parents and material to take home.<br>Theory used=PRECEDE-PROCEDE model, Intervention Mapping<br>Focus=On diet and lifestyle<br>Freq=2 teacher training sessions, 11 games for children<br>C=Normal routine | L=24 weeks; drinking module in week 1 and 4 and 17 and 18<br>FU=1 year | M=4.7 | Five target municipalities were chosen per SES status in each country | I=3080 (6 countries)<br>C=1647 (6 countries) | FFQ<br><br>Ml/day | No | P=63%<br>R=59% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Rangelov, 2018<br>Switzerland | RCT<br>FAN Social Marketing program | I=Web-based social marketing intervention for children and parents using a website and forum (web-only) with SMS (intervention group 1) or with e-mail (intervention group 2) as reminders with tailored communication about nutrition and PA.<br>Theory used=Social Marketing benchmarks.<br>Focus=On diet and lifestyle<br>Freq=Different weekly themes, weekly reminders via SMS/email<br>C=NA | L= 8 weeks<br>FU=8 weeks | M=8.5 | General population | I=web+SMS=194<br>Web+email=196<br>Web-only=218<br>C=NA | 7-day dietary record<br><br>Times/day | No | P=5%<br>R=83% |
| Rauba, 2017<br>USA | Pretest-posttest<br>Energy Up | I=A lesson created by school Wellness Committee (parents, teachers, health professionals) filling plastic bags with sugar and pieces of candy found in SSBs and comparing them to daily limit for age group, restructuring the environment by installation of drinking fountains, distribution of water bottles, and social marketing by school announcements, posters placed in school.<br>Theory used=no theory reported<br>Focus=On beverage consumption<br>Freq=1 lesson, weekly school announcements<br>C=NA | L=4 months<br>FU=6 months | 3rd - 5th grade students | Children of a suburban school | I=211<br>C=NA | 1 24-hr dietary recall<br><br>Times/day | No | P=no info<br>R=99% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Romo, 2018<br>Equador | Pretest-posttest | I=Intervention for children by teachers trained to deliver an educational curriculum, activities, games, traffic light stickers to indicate behavior change all focused on drinking water instead of SSBs engaging in PA and less screen time. Only in the enhanced intervention group parents were trained by teachers and received a workbook with activities for to do with their children at home and refrigerator magnets as rewards for completed activities.<br>Theory used=Social cognitive theory<br>Focus=On diet and lifestyle<br>Freq=1 hr per day on activities<br>C=NA | L= pilot 3 months and enhanced intervention 7 months<br>FU=pilot 3 months and enhanced intervention 7 months | M=3.5 | Children from municipal preschools | I=pilot group=132 enhanced group=144<br>C=NA<br><br>(9 schools in total) | FFQ<br><br>Daily consumption (Y/N) | Yes | P=95%<br>R=90% |
| Siega-Riz, 2011<br>USA | Cluster RCT<br>HEALTHY study | I=Restructuring the environment by changes in the quantity and quality of food offered at school, including cafeteria and afterschool snacks, a la carte and vending machines and messaging, cafeteria-based educational events, taste tests, food staff training sessions, nutrition education classroom and reinforcing healthy behavior through messages, images, events and activities.<br>Theory used: Social marketing principles<br>Focus=On diet and lifestyle<br>Freq=No info<br>C=NA | L= 2.5 years<br>FU=2.5 years (5 school semesters) | M=11.3 | Low income, ethnically diverse | I=1964 (21 public middle schools)<br>C=1944 (21 public middle schools) | FFQ<br><br>Grams/day | Yes | P=no info<br>R=85% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Smit, 2016<br>The Netherlands | Cluster RCT<br>Share H2O | I=Intervention for children by using PIs chosen based on nominations of class-mates were trained to emphasize benefits of water, consume more water themselves, promote water consumption in social network at school.<br>Theory used=Self-persuasion theory, self-determination theory<br>Focus=On beverage consumption<br>Freq= 1 session of 90 min, 2 follow-up sessions<br>C=No intervention | L=9 weeks<br>FU=8 weeks (2 measure points) | M=10.8 | Urban and suburban primary schools | I=106 (2 primary schools)<br>C=104 (2 primary schools) | FFQ<br><br>Glasses/day | Yes | P=14%<br>R=86% |
| Story, 2012<br>USA | Cluster RCT<br>Bright Start | I=Restructuring the school environment including parent involvement and teachers trained to deliver PA in class, food service staff and teachers trained to offer healthy foods and eliminate unhealthy foods, students encouraged to drink water, family events with information, activities, goal setting, take-home incentives and follow-up telephone calls parents.<br>Theory used=Formative assessment, Social Cognitive Theory<br>Focus=On diet and lifestyle<br>Freq=3 family night events, 1 summer event<br>C=No intervention | L=14+31 weeks<br>FU=1.5 years (2 measure points) | M=5.8 | All American-Indian Children | I=267 (8 schools)<br>C=187 (6 schools) | FFQ<br><br>Times drinking bottled water/day | No | P=96%<br>R=92% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Taylor, 2007<br>New Zealand | nRCT<br>Apple project | I=Multifaceted intervention for children at school consisting of restructuring the environment by increased availability of PA, cooled water filters, science lessons with lessons and activities on healthy eating and PA implemented by community activity coordinators.<br>Theory used=no theory reported<br>Focus=On diet and lifestyle<br>Freq=No info<br>C=No intervention | L=2 years<br>FU=2 years (3 measure points) | M=7.7 | Predominantly white | I=151 (4 schools)<br>C=137 (3 schools) | 3-day FFQ<br><br>Servings/3 days | No | P=90%<br>R=62% |
| Van de Gaar, 2014<br>The Netherlands | Cluster RCT<br>the water campaign | I=Multifaceted intervention for children and parents consisting of lessons at school combined with community social marketing campaign and activities that promote water consumption (various e.g. provision water bottle, pimp water bottle, water theme week, posters).<br>Theory used=Intervention mapping, social marketing<br>Focus=On beverage consumption<br>Freq=Various length and duration<br>C=Regular health promotion program | L=1 year<br>FU=1 year (2 measure points) | R=6-12 | Low income, ethnically diverse | I=182 (2 schools)<br>C=205 (2 schools) | FFQ<br><br>L/day | No | P=55% (parents, 84% (children)<br>R=62% (parents), 75% (children) |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Veitch, 2011<br>The Netherlands | Cluster RCT<br>Doit intervene-tion | I=Lessons for children at school by biology and physical education teachers to raise awareness of energy balance behaviors and to facilitate behavioral changes and restructuring the environment by advice to school canteens in availability of foods/drinks.<br>Theory used=Intervention mapping<br>Focus=On diet and lifestyle<br>Freq=11 lessons<br>C=No intervention | L=8 months<br>FU=20 months (4 measure points) | M=12.7 | General population | I=402 (10 schools)<br>C=354 (8 schools) | FFQ<br><br>Ml/day | No | P=74%<br>R=79%-93% |
| Vereecken, 2009<br>Belgium | Cluster RCT<br>Beastly Healthy at School | I=Education and activities at preschool for children by trained school staff, newsletters and evenings for parents, training principals and schools staff a.o about role modeling.<br>Theory used=Intervention mapping protocol, experiential education and developmental education<br>Focus=On diet<br>Freq=2 day training school staff<br>C=No intervention | L=no info<br>FU=6 months (2 measure points) | ≥2.5 | General population | I=308 (8 preschools)<br>C=168 (8 preschools) | FFQ<br><br>Ml/day | No | P=62%<br>R=86% |

**Table S2.** Characteristics and effects of studies included in the review. (Continued)

| Author, year & country | Design & name | Description of the intervention (I) and control (C) condition | Length of intervention and follow-up time | Age in years | Specific characteristics of population | Number participants (& clusters) | Water Assessment & outcome | Significant effect | Participation & retention rate |
|---|---|---|---|---|---|---|---|---|---|
| Waters, 2017<br>Australia | Cluster RCT<br>fun 'n healthy in Moreland | I=Multifaceted content program determined by school strategies about increasing fruit and vegetables, water, PA and self-esteem among children and support by community development workers.<br>Theory used=WHO Health Promoting Schools Framework<br>Focus=On diet and lifestyle<br>Freq=No info<br>C=No intervention | L=3.5 years<br>FU=3.5 years<br>(3 measure points) | M=5-12 | General population | I=1426 (12 schools)<br>C=1539 (10 schools) | 1-day 24hr dietary record<br><br>Water in lunchbox/ canteen order | Yes | P=45%<br>R=95% |
| Wolfe, 2018<br>USA | Pretest-posttest<br>Choose Health: Food, Fun, and Fitness | I=Nutrition education consisting of interactive nutrition activities, preparing or tasting healthy snacks, playing active games, setting weekly goals, take home materials taught by community educators at schools and afterschool programs for children and parents.<br>Theory used=Social cognitive theory, experiential learning model<br>Focus=On diet and lifestyle<br>Freq=6 weekly lessons of 45-90 min<br>C=NA | L= 6 weeks<br>FU=6 weeks<br>(2 measure points) | 3rd - 5th grade students | Low income ethnically diverse | I=686<br>C=NA | FFQ<br><br>Frequency drinking water | Yes | P=No info<br>R=No info |

*+=non-significant positive, ++ significant positive, -non-significant negative, / unclear non-significant; a.o=amongst others; BMI=body mass index; C=control; comm=community; fam= family; FFQ=food frequency questionnaire; FU=follow-up; h=hours; I=intervention; L=length/liters; min=minutes; ml=milliliter; NA=not applicable; nRCT=non-randomized controlled trial; NYC=New York City; P=participation rate; PA=physical activity; PI=peer influencer; R=range; RCT= randomized controlled trial; R=retention rate; SES=socioeconomic status; SSB=sugar sweetened beverage; TTT=teach the teacher; USA Islands=Alaska, American Samoa, Commonwealth of the Northern Mariana Islands, Guam, and Hawaii; WIC=nutritional program for women infants and children.

**Table S3**. Risk of bias randomized controlled trials.

| | Random sequence generation bias | allocation conceal-ment bias | Blinding of participants, personnel and outcome assessors bias | Incomplete outcome bias | Selective outcome reporting bias | Other sources of bias (measurement outcomes, departures intended interventions, choice statistical methods) | Overall risk of bias |
|---|---|---|---|---|---|---|---|
| Baranowski,2011 | unclear | unclear | low | low | low | low | **unclear** |
| Beets, 2017 | low | low | low | low | low | low | **low** |
| Contento, 2010 | unclear | low | unclear | low | low | high | **high** |
| Crespo, 2012 | unclear | unclear | unclear | high | low | high | **high** |
| de Bock, 2016 | unclear | low | unclear | high | high | high | **high** |
| de Coen, 2012 | high | low | high | high | high | high | **high** |
| Elder, 2014 | unclear | unclear | unclear | low | high | high | **high** |
| Franken, 2018 | unclear | low | low | low | low | high | **high** |
| Giles, 2012 | unclear | low | unclear | low | low | low | **unclear** |
| James, 2004 | low | low | low | high | low | unclear | **high** |
| Kaufman Shriqui, 2016 | low | low | low | low | low | high | **high** |
| Klesges, 2010 | low | unclear | low | low | low | low | **unclear** |
| McGowan, 2013 | low | low | high | low | low | high | **high** |
| Novotny, 2018 | low | unclear | unclear | low | low | low | **unclear** |
| Patel, 2016 | low | unclear | unclear | low | low | high | **high** |

**Table S3**. Risk of bias randomized controlled trials. (Continued)

| | Random sequence generation bias | allocation conceal-ment bias | Blinding of participants, personnel and outcome assessors bias | Incomplete outcome bias | Selective outcome reporting bias | Other sources of bias (measurement outcomes, departures intended interventions, choice statistical methods) | Overall risk of bias |
|---|---|---|---|---|---|---|---|
| Pinket, 2016 | low | unclear | unclear | high | low | high | **high** |
| Rangelov, 2018 | low | low | unclear | low | low | high | **high** |
| Siega-Riz, 2011 | low | low | unclear | unclear | low | high | **high** |
| Smit, 2016 | unclear | unclear | unclear | low | low | high | **high** |
| Van der Gaar, 2014 | low | low | unclear | high | low | high | **high** |
| Story, 2012 | unclear | unclear | unclear | unclear | low | high | **high** |
| Veitch, 2011 | low | low | high | unclear | low | high | **high** |
| Vereecken, 2009 | unclear | unclear | unclear | low | high | high | **high** |
| Waters, 2017 | low | low | low | low | low | high | **high** |

**Table S4.** Risk of bias non-randomized controlled trials and non-controlled quasi-experimental studies.

| Author, year | Bias due to confounding (age, sex, baseline) | Bias in selection of participants into the study | Bias in classification of interventions | Bias due to departures from intended interventions | Bias due to missing data | Bias in measurement of outcomes | Bias in selection of the reported result | Overall risk of bias |
|---|---|---|---|---|---|---|---|---|
| **Abi Haidar, 2011** | serious | low | NA | NA | moderate | serious | moderate | **serious** |
| **Bea, 2015** | moderate | moderate | NA | NA | moderate | serious | moderate | **serious** |
| **Beets, 2014** | serious | moderate | NA | NA | unclear | moderate | moderate | **serious** |
| **Bender, 2013** | serious | serious | NA | NA | serious | serious | moderate | **serious** |
| **Brand, 2017** | moderate | serious | NA | NA | moderate | serious | moderate | **serious** |
| **Canavera, 2009** | serious | serious | NA | NA | unclear | serious | moderate | **serious** |
| **De Bourdeaudhuij, 2015** | moderate | moderate | low | serious | serious | serious | moderate | **serious** |
| **de Silva-Sanigorski, 2010** | moderate | moderate | low | unclear | critical | serious | moderate | **critical** |
| **Elder, 2014** | serious | moderate | low | moderate | serious | serious | moderate | **serious** |
| **Franks, 2017** | serious | serious | low | moderate | moderate | moderate | moderate | **serious** |
| **Freedman, 2010** | serious | critical | NA | serious | serious | serious | serious | **critical** |
| **Galvan, 2016** | moderate | low | NA | unclear | moderate | serious | moderate | **serious** |
| **Gittelson, 2010** | moderate | moderate | low | moderate | unclear | serious | serious | **serious** |
| **Hornsby, 2017** | moderate | moderate | NA | serious | unclear | serious | serious | **serious** |
| **Laurence, 2007** | serious | moderate | NA | unclear | serious | serious | moderate | **serious** |
| **Majumdar, 2013** | serious | moderate | low | moderate | serious | serious | moderate | **serious** |
| **McGarvey, 2004** | serious | moderate | low | moderate | serious | serious | moderate | **serious** |

**Table S4.** Risk of bias non-randomized controlled trials and non-controlled quasi-experimental studies. (Continued)

| Author, year | Bias due to confounding (age, sex, baseline) | Bias in selection of participants into the study | Bias in classification of interventions | Bias due to departures from intended interventions | Bias due to missing data | Bias in measurement of outcomes | Bias in selection of the reported result | Overall risk of bias |
|---|---|---|---|---|---|---|---|---|
| **Muckelbauer, 2009** | moderate | low | low | moderate | moderate | serious | moderate | **serious** |
| **Patel, 2011** | moderate | moderate | moderate | moderate | moderate | serious | moderate | **serious** |
| **Rauba, 2017** | serious | moderate | NA | unclear | low | serious | moderate | **serious** |
| **Romo, 2018** | serious | moderate | NA | unclear | moderate | serious | serious | **serious** |
| **Taylor, 2007** | moderate | moderate | low | unclear | serious | moderate | moderate | **serious** |
| **Wolfe, 2018** | serious | unclear | NA | unclear | unclear | serious | serious | **serious** |

Abbreviation: NA=not applicable

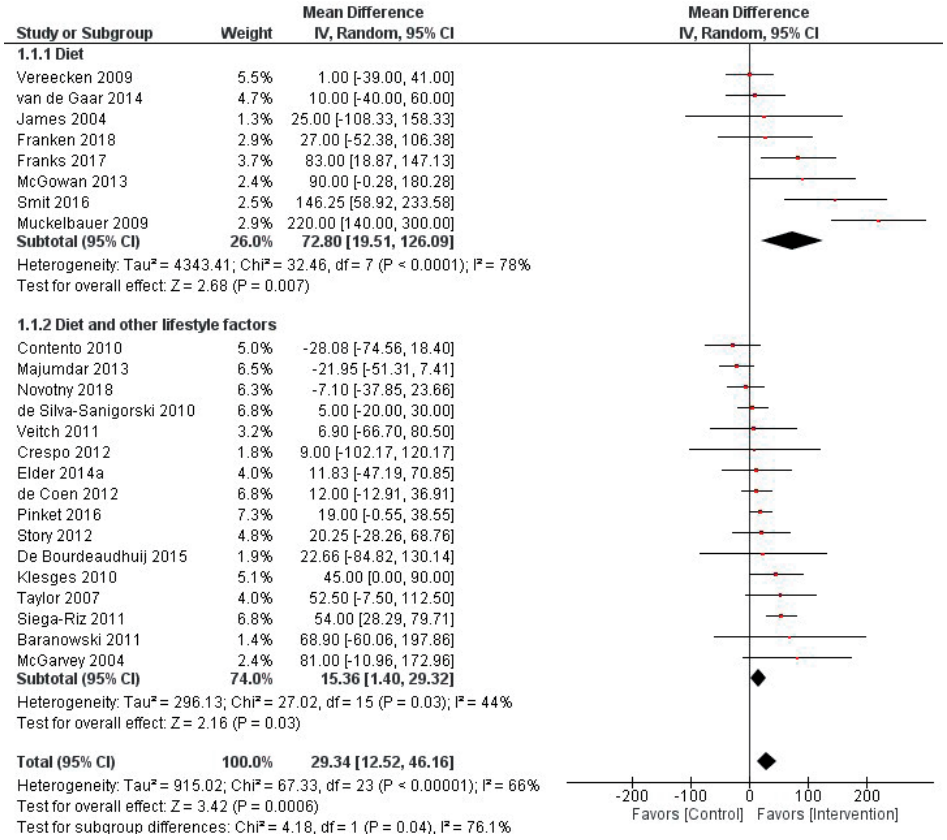


**Figure S1.** Effect by focus of intervention.

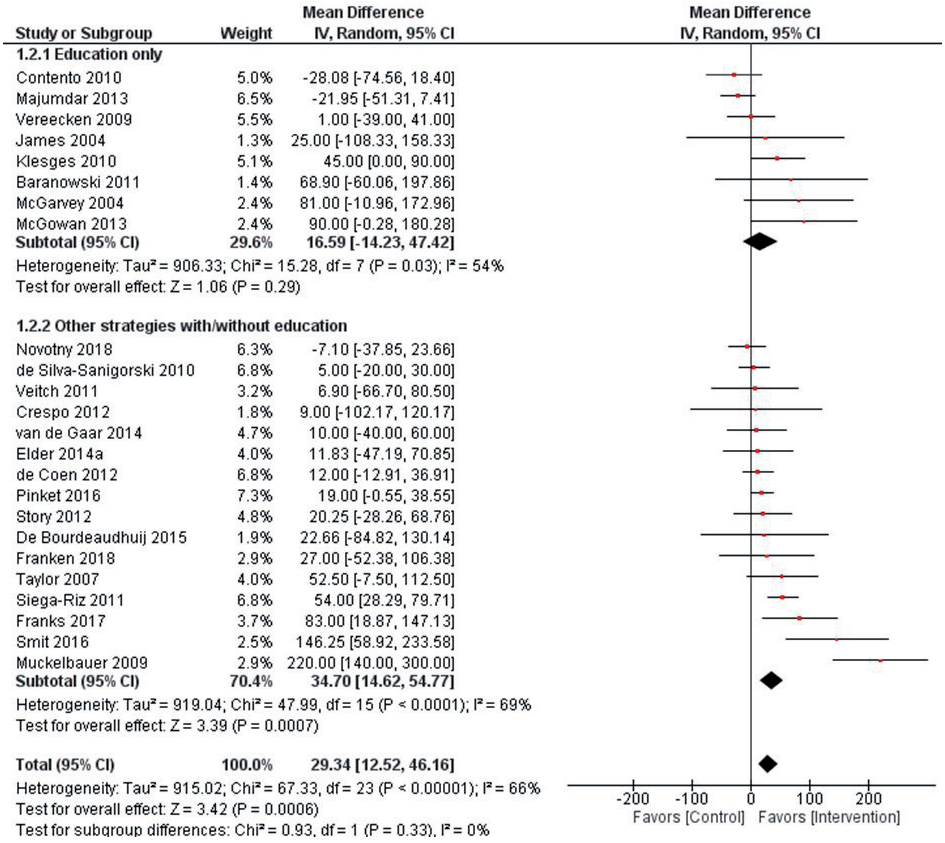


**Figure S2.** Effect by intervention strategy.

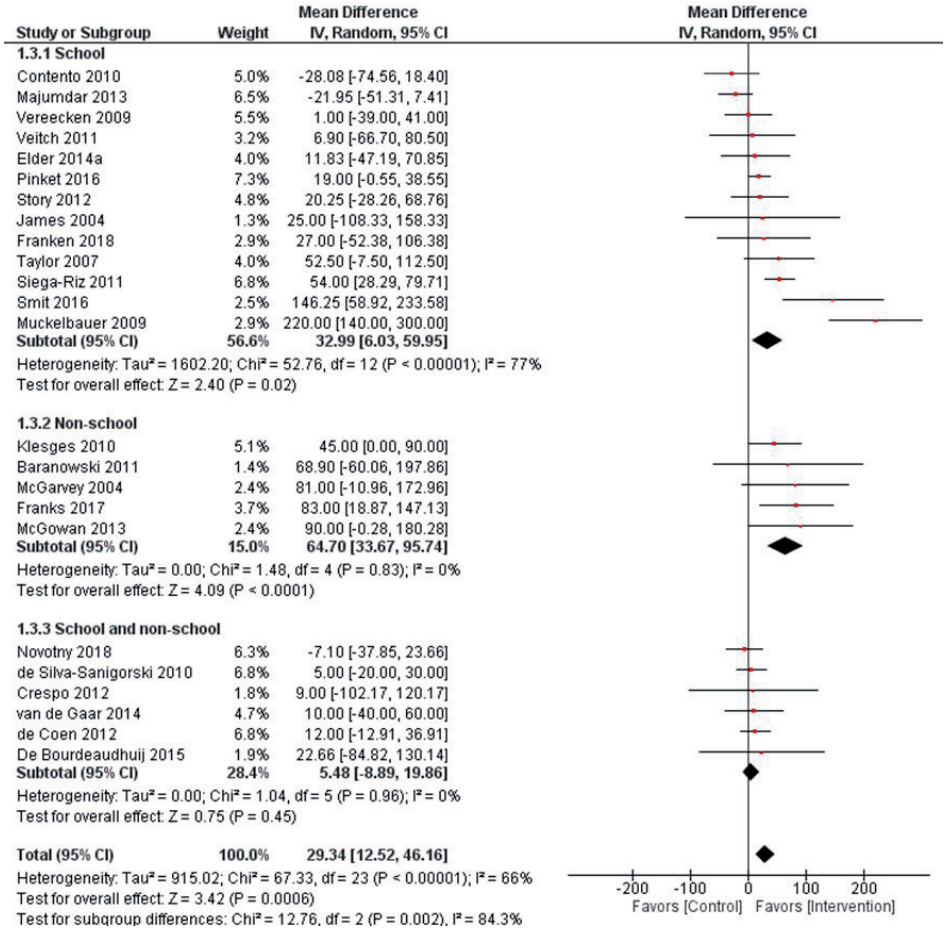


**Figure S3.** Effect by intervention setting.

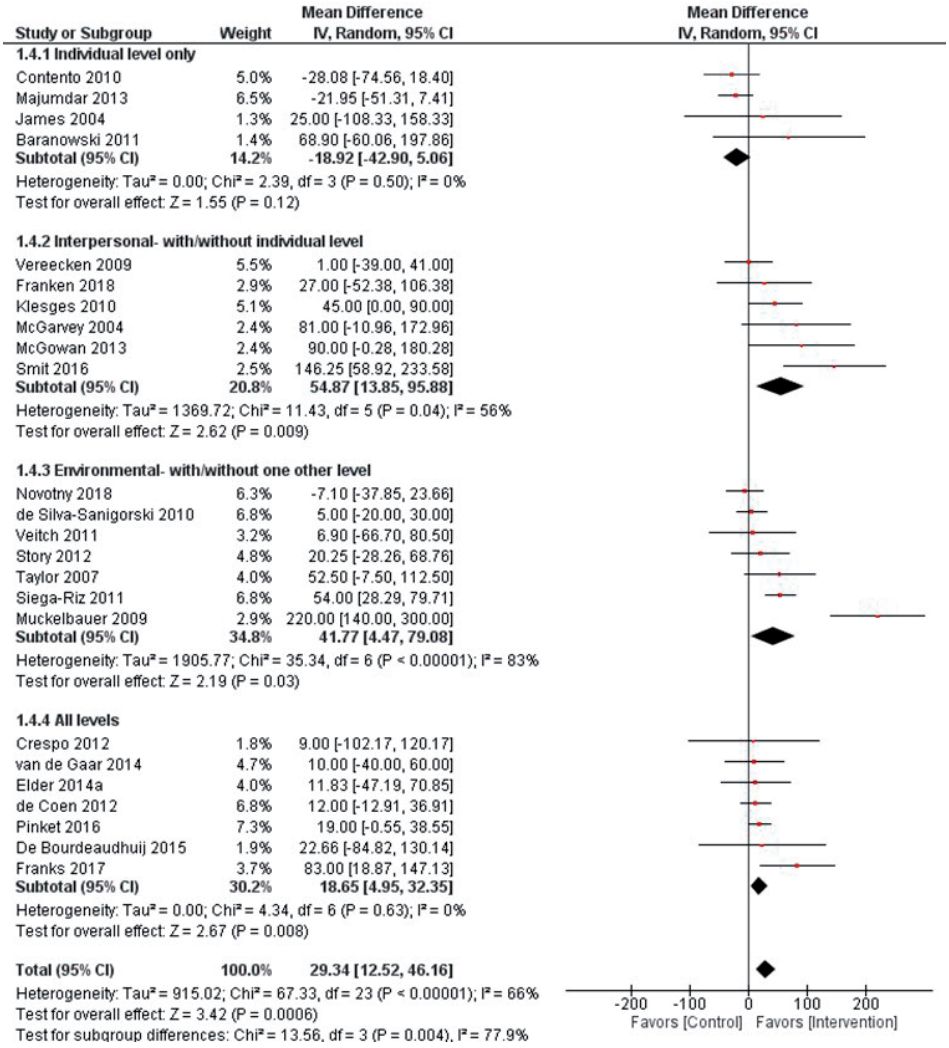


**Figure S4.** Effect by socioecological level targeted.

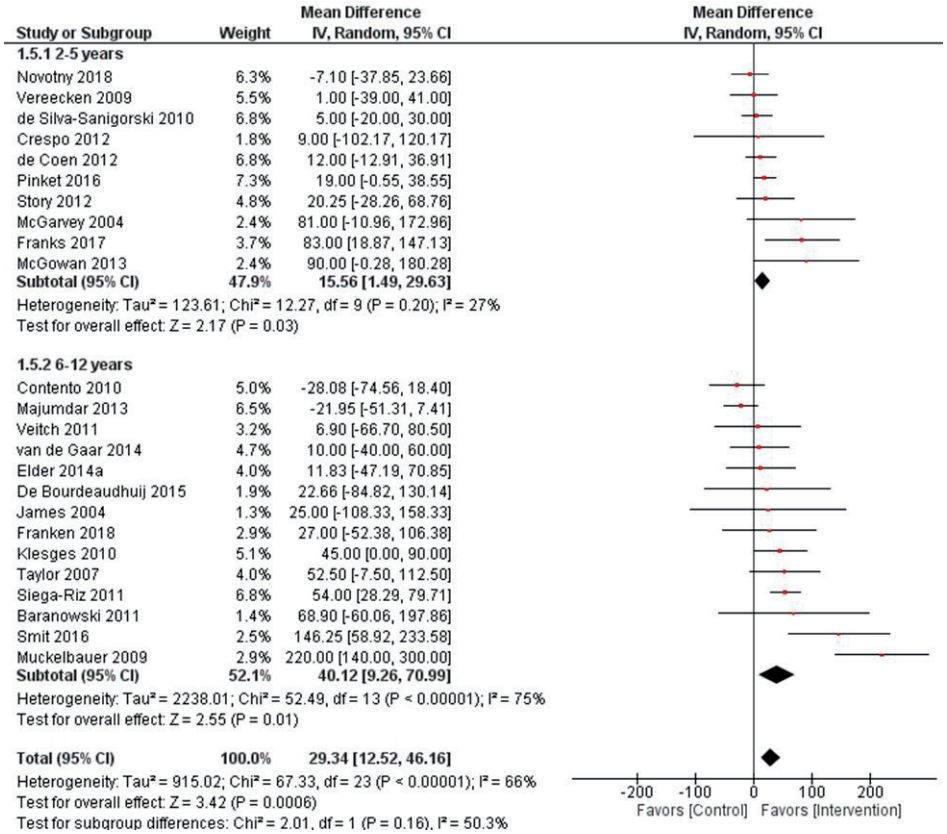


**Figure S5.** Effect by mean age children.

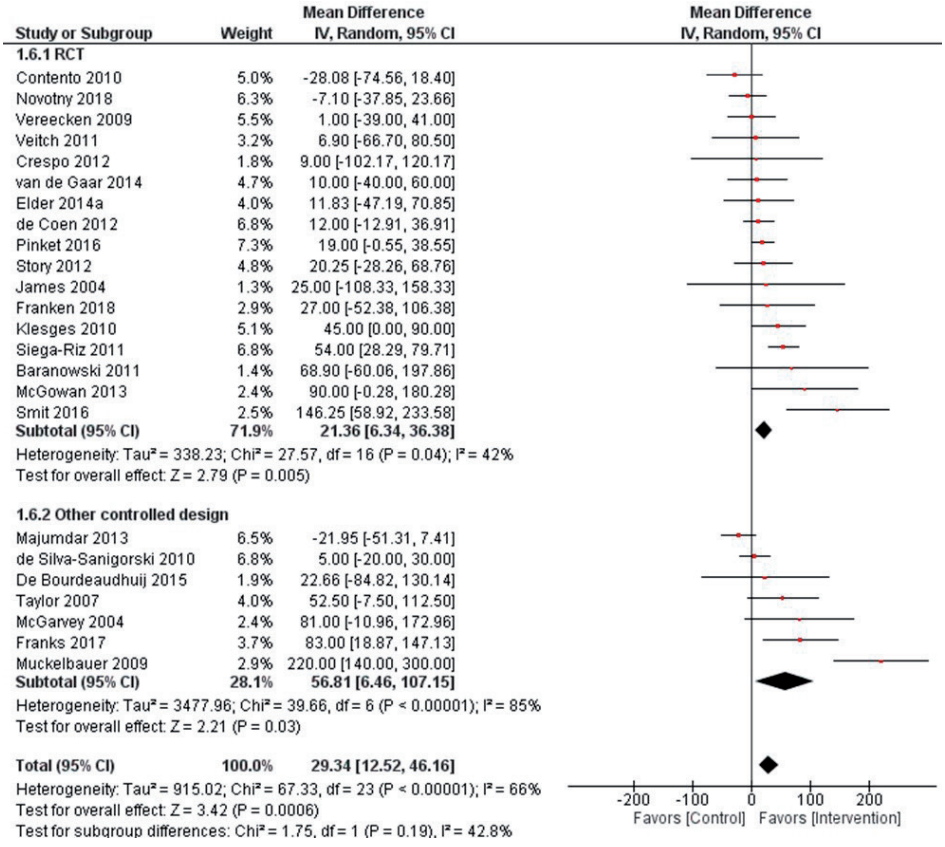


**Figure S6.** Effect by study design.

| Study or Subgroup | Intervention Mean | SD | Total | Control Mean | SD | Total | Weight | Mean Difference IV, Random, 95% CI |
|---|---|---|---|---|---|---|---|---|
| James 2004 | 358.33 | 166.7 | 295 | 425 | 166.67 | 279 | 5.5% | -66.67 [-93.95, -39.39] |
| Contento 2010 | 510.93 | 350.19 | 460 | 539.01 | 359.59 | 437 | 4.9% | -28.08 [-74.56, 18.40] |
| Novotny 2018 | 302.84 | 1,060.4932 | 1342 | 326.494 | 651.0815 | 1295 | 4.3% | -23.65 [-90.56, 43.25] |
| Majumdar 2013 | 360.92 | 131.99 | 182 | 382.87 | 143 | 159 | 5.4% | -21.95 [-51.31, 7.41] |
| Vereecken 2009 | 274 | 212 | 308 | 273 | 212 | 168 | 5.2% | 1.00 [-38.85, 40.85] |
| Veitch 2011 | 455.94 | 474.3 | 402 | 453.391 | 503.7 | 354 | 4.1% | 2.55 [-67.47, 72.57] |
| Crespo 2012 | 654.75 | 409.5 | 83 | 645.75 | 400.5 | 134 | 2.9% | 9.00 [-102.17, 120.17] |
| van de Gaar 2014 | 670 | 280 | 182 | 660 | 290 | 205 | 4.6% | 10.00 [-46.84, 66.84] |
| Elder 2014a | 570.18 | 328.49 | 238 | 558.352 | 340.7 | 256 | 4.5% | 11.83 [-47.19, 70.85] |
| de Coen 2012 | 327 | 168 | 396 | 315 | 164 | 298 | 5.5% | 12.00 [-12.91, 36.91] |
| Pinket 2016 | 583 | 328 | 3080 | 564 | 326 | 1647 | 5.6% | 19.00 [-0.55, 38.55] |
| Story 2012 | 189 | 257.36 | 267 | 168.75 | 246.1 | 187 | 4.9% | 20.25 [-26.62, 67.12] |
| De Bourdeaudhuij 2015 | 702.6408 | 2,934.4165 | 5727 | 679.985 | 2,826.7244 | 5314 | 3.0% | 22.66 [-84.82, 130.14] |
| Klesges 2010 | 180 | 242.3 | 116 | 135 | 253.56 | 127 | 4.4% | 45.00 [-17.36, 107.36] |
| Siega-Riz 2011 | 483 | 420 | 1964 | 429 | 400 | 1944 | 5.5% | 54.00 [28.29, 79.71] |
| Taylor 2007 | 585 | 270 | 151 | 517.5 | 300 | 137 | 4.3% | 67.50 [1.33, 133.67] |
| Baranowski 2011 | 364.3 | 319.4 | 93 | 295.4 | 308.58 | 40 | 2.8% | 68.90 [-46.68, 184.48] |
| McGarvey 2004 | 806.625 | 429 | 121 | 725.63 | 372 | 65 | 2.7% | 81.00 [-37.42, 199.41] |
| Franks 2017 | 254.4 | 219.5 | 72 | 171.4 | 156.5 | 61 | 4.3% | 83.00 [18.87, 147.13] |
| McGowan 2013 | 607.5 | 247.5 | 51 | 517.5 | 225 | 55 | 3.5% | 90.00 [-0.28, 180.28] |
| Franken 2018 | 1,067 | 438.5 | 192 | 961.43 | 406.12 | 185 | 3.6% | 105.57 [20.29, 190.85] |
| Smit 2016 | 657 | 324.31 | 106 | 510.75 | 321.2 | 104 | 3.6% | 146.25 [58.94, 233.56] |
| Muckelbauer 2009 | 244.785 | 620.4144 | 1070 | -10.578 | 581.2697 | 917 | 4.7% | 255.36 [202.47, 308.25] |
| **Total (95% CI)** | | | **16898** | | | **14368** | **100.0%** | **37.43 [10.87, 63.99]** |

Heterogeneity: Tau² = 3152.66; Chi² = 158.98, df = 22 (P < 0.00001); I² = 86%
Test for overall effect: Z = 2.76 (P = 0.006)

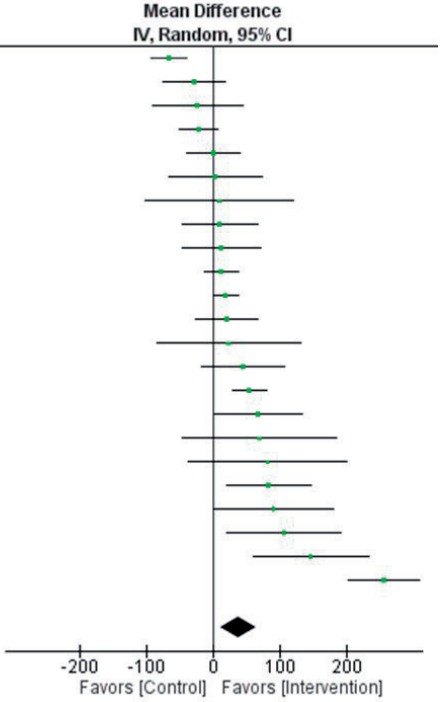


**Figure S7.** Sensitivity analysis random-effects meta-analysis of the mean difference in children's water consumption (in ml/day) between intervention and control group (N=24).

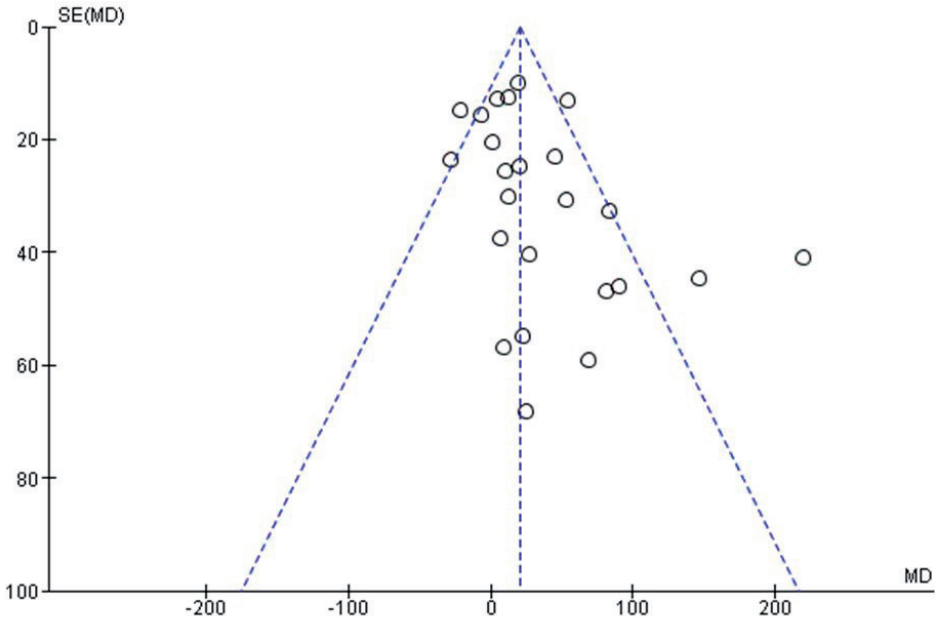


**Figure S8.** Funnel plot of the mean difference (MD) in millilitre water consumption between intervention and control group against the standard error (SE) of the MD of all studies included in the meta-analysis.

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8

# Evaluation of the promising neighbourhoods community program to reduce health inequalities in youth: a protocol of a mixed-methods study

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## ABSTRACT

**Background:** Reducing socioeconomic health inequalities among youth is a major challenge for governments around the world and reports on successful attempts are scarce. Socioecological and integral approaches with collaborative partnerships and community engagement are recommended but knowledge about the effectiveness and effective and ineffective elements is limited. The Promising Neighbourhoods program employs such an approach aiming to reduce socioeconomic inequalities in health, safety and talent development in youth. We will evaluate the process-implementation, and effectiveness of the Promising Neighbourhoods program.

**Methods/design:** Core elements of Promising Neighbourhoods are a collaborative community programming approach with stakeholders, data-based priority setting, knowledge-, and theory-based policies and evidence-based interventions. Community stakeholders and key-leaders from the neighbourhoods are engaged in the program. For this evaluation study the program will be implemented in three intervention neighbourhoods. These neighbourhoods will be compared to three control neighbourhoods at baseline in 2018/2019 and at follow-up in 2020/2021 after full implementation of the Promising Neighbourhoods program. Intervention neighbourhoods receive a tailored intervention-package including evidence-based interventions and additional measures by community stakeholders. In control neighbourhoods, no special planning will take place thus interventions are offered as usual. A mixed-methods approach following the stages of the logic model from the program is applied for this evaluation. Questionnaires, focus groups, and registration data will be collected among community stakeholders, key-leaders, and youth to evaluate the process-implementation of the program. Indicators of intermediate and ultimate outcomes will be studied among N=818 children and N=818 youngsters using difference-in-difference regression analysis to evaluate the effectiveness of the Promising Neighbourhoods program.

**Discussion:** Hypotheses are that a collaborative community approach with stakeholders leads to clear priority-setting and better tailored interventions of better quality. We further hypothesise a decline in socioeconomic inequalities in intermediate and ultimate outcomes for health, safety and talent development in the intervention neighbourhoods in comparison to control neighbourhoods. The results add knowledge about effective and ineffective elements of collaborative community programming approaches to reduce health inequalities in youth and thus are relevant for local and national public health authorities.

**Trial registration:** Netherlands National Trial Register number NL7279 Date of registration: 26-Sept-2018.

## BACKGROUND

Reducing socioeconomic health inequalities is a major challenge for governments around the world and many investments have been made in developing strategies and programs to reduce inequalities (1-4). However, no convincing reductions in health inequalities at population level have been reported and even an increase is mentioned (5). Neighbourhood quality, parenting, family life, and the bio-socio-emotional development of youth are thought to explain at least part of the association between socioeconomic conditions and health inequalities (5, 6). Epidemiological research demonstrated health inequalities in (mental) health status, youth physical activity, school performance, safety, and health related behaviours (7). In the long term adverse socioeconomic conditions could result in vulnerabilities affecting the perspectives of youth.

To promote health at the local level, socioecological, integral approaches, collaborative partnerships and community engagement are recommended by Weiss *et al.,* and the World Health Organization (7, 8). Local governments are pivotal in targeting health inequalities, because of their responsibility for social and health policies and their involvement in organising the delivery of social and health services. Furthermore, local governments are in a strong position to bring local actors together for collaboration (9). At present, knowledge is still limited on how local governments, including municipalities, can successfully implement such integral collaborative community programs, developed in collaboration with community stakeholders. Also, knowledge about what factors determine program successes and failures is still limited (8-10). The scoping review by Weiss *et al.,* mentions facilitators for successful implementation of collaborative community programs such as the Rural Mental Health project (8). The Rural Mental Health Project is a promising program targeting mental health, well-being and employment in two rural communities in Northern Ireland (11-13). The most frequently mentioned facilitating factors are multidisciplinary collaboration, trust between stakeholders, community engagement and inclusion, local planning and action, adequate resources and the use of a dynamic approach (8). However, most of the studies included in this scoping review are programs targeted at adults, and not much is known about local community programs targeting youth (8).

Two examples of collaborative community programs that are aimed at promoting the health and well-being of youth are Ensemble Prévenons l'Obésité Des Enfants/Together

Let's Prevent Obesity (EPODE) and Communities that Care (CtC) (14-24). EPODE uses an integrated community-based approach and includes stakeholders at the national and local level (14). Variations of EPODE are implemented in several countries. Twelve years after initiation of the first EPODE school- and community based program in France, downward trends in overweight prevalence and obesity prevalence were demonstrated (15). A downward trend was also demonstrated in Belgium but not in Spain (25, 26). A process evaluation of 18 EPODE programs among several countries demonstrated that good relations between the local project coordinator, program implementers and stakeholders are seen as an important factor for the effectiveness of EPODE (16). CtC is an integral community prevention coalition aiming to reduce substance abuse and anti-social behaviour among youth and implemented in several countries including the United States of America (USA), United Kingdom and the Netherlands. CtC was evaluated by the Community Youth Development study in seven matched USA states. The participants in CtC communities were more likely to have abstained from cigarettes, alcohol and drugs compared to control communities (18, 23, 24). In the United Kingdom and the Netherlands, the results were mixed. For the Netherlands disappointing results are explained by shortcomings in internal validity and study design such as lack of tested and effective preventive interventions, contamination and small sample sizes (17, 19, 27-29). Process evaluations demonstrated that CtC communities had a greater adoption of a science-based approach and used more effective interventions compared to control communities (17, 20-22). Even though these collaborative community programs showed mixed results they demonstrated some important facilitators for successful implementation, and more needs to be learned about their effective and less effective elements to be able to design effective and integral policies and implementation strategies on the local level (8, 30).

Rotterdam, the second largest city in the Netherlands, has many deprived inner-city neighbourhoods. Around one in five of the children and youngsters in this city are raised in poverty (31). Reducing poverty and socioeconomic health inequalities are recognized as a major challenge by the municipality (31). The Promising Neighbourhoods program was developed with the aim to decrease health inequalities and to increase health, safety and talent development among youth. A collaborative community approach with stakeholders, using data-based priority setting, knowledge-, and theory-based policies and with evidence-based interventions in a package tailored to the needs of each specific neighbourhood are the core of the Promising Neighbourhoods program. A thorough process- implementation and effect evaluation of the Promising Neighbourhoods program is set up to disentangle which factors are important for successful implementation of these types of collaborative community approaches and to determine the effectiveness. The Promising Neighbourhoods program will be implemented

in intervention neighbourhoods which will be compared to control neighbourhoods. This paper describes the design and methodology of the evaluation study of Promising Neighbourhoods.

### Research questions

The first research question is: how does the process-implementation of the program evolve and what are effective and less effective steps and elements of the Promising Neighbourhoods program? The second research question is: what is the effectiveness of the Promising Neighbourhoods program on reducing socioeconomic inequalities in intermediate outcomes (determinants: protective and risk factors) and ultimate outcomes (health, safety, and talent development) in youth.

### Study hypothesis

We hypothesise that a collaborative community programming approach with stakeholders leads to clear priority setting and better tailored interventions of better quality. Further, we hypothesise a decline in socioeconomic inequalities in intermediate and ultimate outcomes for health, safety and talent development in intervention neighbourhoods in comparison to control neighbourhoods. Intermediate outcomes include the following indicators of risk and protective factors targeted by the program Promising Neighbourhoods: family environment, healthy exercise, nutrition behaviours, smoking and substance use, social cohesion, use of facilities and care and bullying. Ultimate outcomes are indicators of health, safety and talent development.

## METHODS/DESIGN

### Description of the Promising Neighbourhoods program

The Promising Neighbourhoods program is part of the youth policy 'Rotterdam Grows 2015-2020' of the municipality of Rotterdam (32). This youth policy is based on a multilevel socioecological framework of interrelated risk and protective factors in the life course from pregnancy to young adulthood, including socioeconomic factors (see fig. 1). This framework provides the theoretical foundation for an integral youth policy program to achieve improvements in several interrelated youth policy domains. The Promising Neighbourhoods program uses this framework and partly builds on experience of methodologies like the community-based EPODE program and the CtC approach (20, 33). Aims of the Promising Neighbourhoods program are to decrease health inequalities and to increase health, safety, and talent development in youth. The Promising Neighbourhoods program focuses on prevention, stimulation of development, capacity building, empowerment of youth and their families, and improvement of neighbourhood quality,

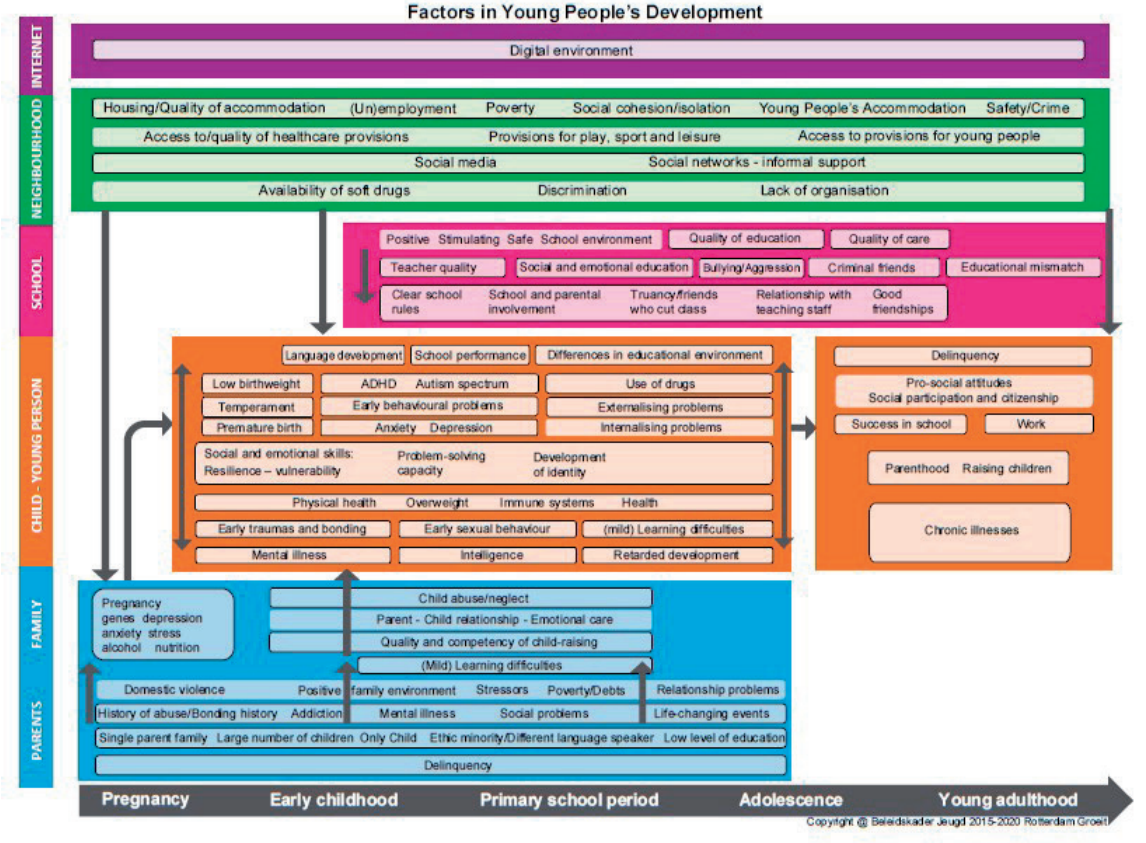


**Figure 1.** Socioecological framework of the Rotterdam Youth Policy Framework 2015-2020.
This socioecological framework provides an overview of parental/family, child-youth, school and community risk and protective factors that influence the development of children from pregnancy to young adulthood onward.

using a collaborative community programming approach with stakeholders, data-based priority setting, knowledge-, and theory-based policies and evidence-based interventions.

The collaborative community programming approach is managed by municipal district advisors. Each municipal district advisor is assigned to a different neighbourhood and will coordinate and monitor the collaborative community programming approach. Every municipal district advisor plans a neighbourhood tailored intervention-package consisting of parenting support, preventive (health) interventions, youth welfare, measures, facilities and activities to improve preventive factors and reduce risk factors for health, safety and talent development among youth. Each neighbourhood receives a tailored intervention-package according to the individual needs of that particular neighbourhood. These needs are assessed using quantitative indicators of the underlying protective and risk factors (corresponding to the theoretical framework) and in consultation with the community stakeholders and key-leaders within the neighbourhood network. The collaborative community programming approach consists of eight steps.

In step one, the needs-assessment of the neighbourhood will be performed using routinely collected data by the municipality of Rotterdam in the so-called Youth Monitor database (34). This monitor comprises of around 250 quantitative indicators in the areas of health, safety and talent development. The data are collected from various sources, including Statistics Netherlands (CBS), police databases, survey data and routinely collected registration data by health professionals of the Child & Family Centres. These Child & family centres provide basic preventive health services and function as intermediaries for specialized youth care providers. The indicators in the Youth Monitor database correspond to the risk and protective factors in the above-mentioned theoretical framework. The theoretical framework is used by the municipal district advisors to interpret the data and relations between the findings about priorities in the neighbourhood. Based on the outcomes of the needs-assessment, the municipal district advisors suggest what the priorities should be. At the end of this step, the municipal district advisors prepare a first draft of the needs-assessment report. In step two, the draft needs-assessment report of each neighbourhood is discussed with community stakeholders to match the conclusions based on the quantitative data with their daily experiences and to gain local support by setting joint goals. Subsequently, in step three, the needs-assessment report is adapted based on input of the community stakeholders resulting in a final needs-assessment report of the neighbourhood. In step four, the municipal district advisors inventory the currently available measures, interventions, facilities and activities in the neighbourhood and assess their presence in the so-called database Effective Youth Interventions (EYI) of the Netherlands Youth Institute (NYI) (35). This is a comprehen-

sive database of all nationally available evidence-based interventions for children and youngsters. The municipal district advisors will do this in collaboration with community stakeholders. In step five, outcomes of step four are discussed by the municipal district advisors with community stakeholders to assess which providers and which measures, interventions, facilities and activities are needed to complete the neighbourhood tailored intervention-package. Priority will be given to EYI database of the Netherlands Youth Institute (NYI) (35). In step six, a detailed neighbourhood intervention-package plan is drawn and all measures, interventions, facilities and activities that will be implemented are described. In step seven, the intervention-package plan including the proposed measures, interventions, facilities and activities is implemented in the neighbourhood. At last, step eight consists of continuous monitoring and revision of the intervention-package performed by municipal district advisors and community stakeholders in the neighbourhood. The monitoring consists of qualitatively and quantitatively evaluating whether intervention-packages in the neighbourhood have the intended results or not, why the results were achieved or not, and what can be done to achieve the previously set goals.

## Intervention neighbourhoods

The Promising Neighbourhoods program will be implemented in three intervention neighbourhoods as described above.

## Control Neighbourhoods

In three comparable control neighbourhoods the Promising Neighbourhoods program will not be implemented during this evaluation study. Preventive measures, interventions, activities and facilities will take place in the control neighbourhoods as usual but there will be no collaborative community programming with stakeholders no data-based priority setting and no promotion of knowledge-, and theory-based policies and evidence-based interventions.

## Evaluation strategy using a logic model

To evaluate the Promising Neighbourhoods program, a logic model is used (see Fig. 2). This logic model is used as overall guiding framework for the evaluation study (36). The logic model contains five stages: assets, input, output, intermediate outcomes and ultimate outcomes. All elements of the logic model, i.e. all different stages of the Promising Neighbourhoods program, will be studied and evaluated. The assets, input and output correspond with the process-implementation evaluation and the intermediate and ultimate outcomes correspond with the effect evaluation. The 'assets stage' consists of existing data and information about the participating neighbourhoods, the support from partners, community stakeholders, sponsors, and target groups in the neighbour-

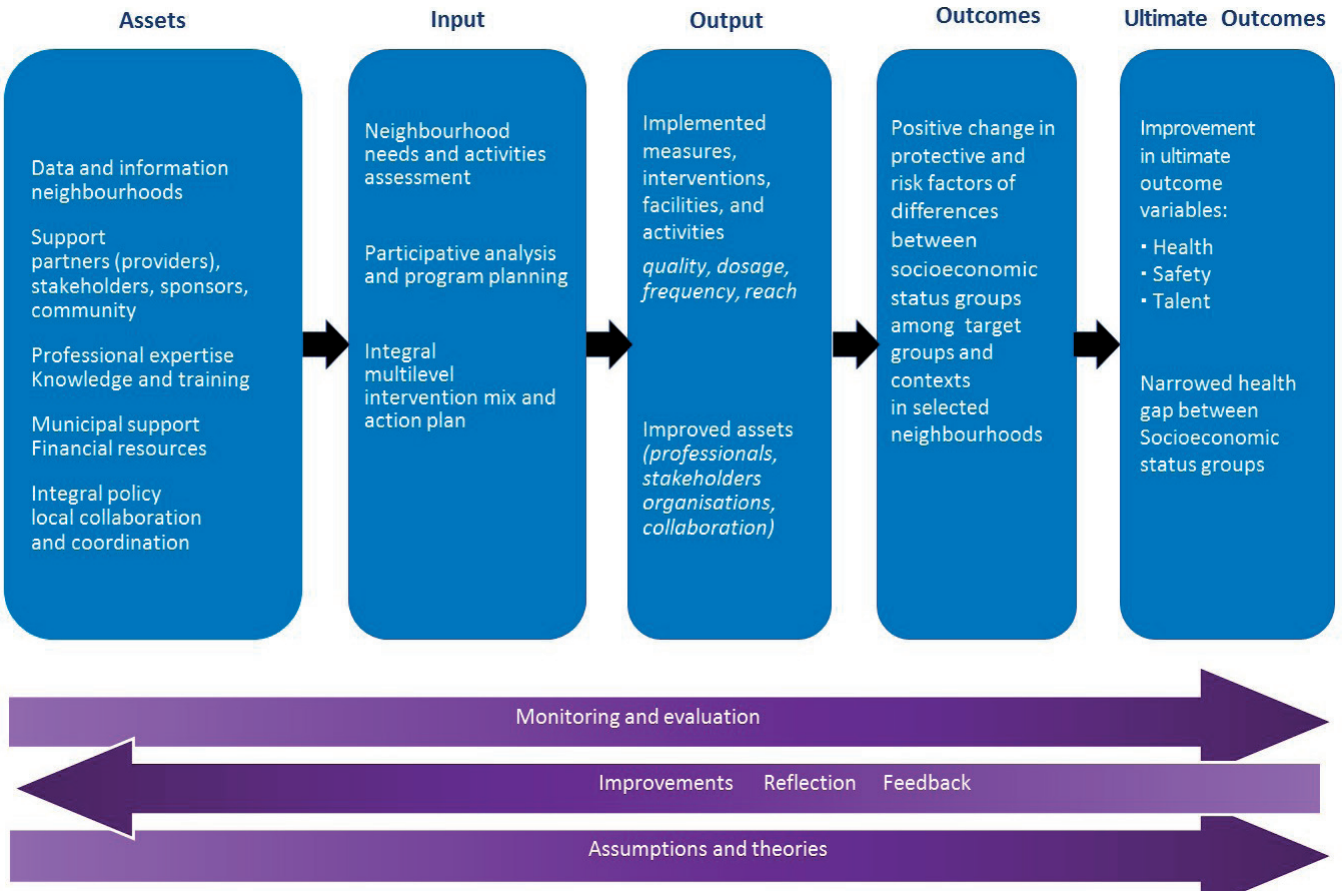


**Figure 2.** Logic model for the Promising Neighbourhoods evaluation study.

hoods, municipal support, financial resources, expertise, knowledge, local collaboration and coordination. The 'input stage' includes the neighbourhood-specific needs-assessment of the municipal district advisors together with community stakeholders, the assessment of measures, interventions, facilities and activities, already present the in neighbourhood and the intervention-package and action plan. The 'output stage' includes the type, number, frequency, intensity, quality, costs and reach of the measures, interventions, facilities and activities and improved assets such as capacity building and empowerment. Targeted intermediate outcomes are improvements in risk and protective factors of youth health, safety and talent development. The targeted ultimate outcomes are improvements of socioeconomic inequalities in health, safety, and talent development among youth in Rotterdam.

## Study design

The study consists of a process-implementation and effect evaluation of the Promising Neighbourhoods program using a mixed-methods design. The process-implementation evaluation corresponds to the assets, input and output of the logic model. Important elements such as reach, dose delivered, dose received and program fidelity from process-implementation evaluation strategies are incorporated in this evaluation (37, 38). For the process-implementation evaluation, qualitative and quantitative measurements will be performed at baseline (T0) and at follow-up after implementation (T1) of the Promising Neighbourhoods program. Qualitative measurements will be performed using questionnaires and focus groups. Quantitative measurements will be performed using register-data and questionnaires. The effect evaluation corresponds with the intermediate and ultimate outcomes of the logic model. The effect evaluation is based on two separate cross-sectional samples and routinely collected data at baseline and at follow-up after implementation of the full Promising Neighbourhoods program.

## Setting

This study is carried out in six different neighbourhoods in Rotterdam. Neighbourhoods in Rotterdam are categorized as low, middle or high based on the degree of experienced problems. The categorization is based on the percentage of children aged 4 and 12 years old with a high score on the Strengths and Difficulties Questionnaire (SDQ) and the percentage of overweight children in grade two of primary school in the neighbourhoods (34). The SDQ is a validated questionnaire to measure emotional problems, conduct problems, hyperactivity/inattention, peer problems, prosocial behaviour and total difficulties score (39). From each category an intervention neighbourhood was selected resulting in three intervention neighbourhoods. Intervention neighbourhoods were matched to control neighbourhoods as much as possible on these two experienced problems and on average socioeconomic status of the neighbourhoods.

## Study population

For the process-implementation evaluation of the Promising Neighbourhoods program, three different groups are distinguished for data collection at baseline as well as at follow-up after the implementation. The first group consists of all community stakeholders in the field of youth (such as teachers, police officers, youth -, health, social -, community -, and sports workers) in each intervention neighbourhood and each control neighbourhood. We want to include all community stakeholders per neighbourhood, and we expect that the size of the population will range between 30-50. The second group consists of youngsters (aged ≥12-18 years) in the intervention neighbourhoods, and a comparable group of youngsters in the control neighbourhoods. We will include eight to ten youngsters from intervention neighbourhoods and eight to ten youngsters from control neighbourhoods. The third group consists of key-leaders who are participating in the Promising Neighbourhoods program in each intervention neighbourhood and a comparable group of key-leaders in each control neighbourhood. Key-leaders of the community know the neighbourhood from inside and are for example: police officers, school superintendents, heads of social services agencies, persons knowledgeable about prevention efforts in the community and municipal district advisors managing the process-implementation of the Promising Neighbourhoods program. We will include eight to ten key-leaders per neighbourhood.

For the effect evaluation of the Promising Neighbourhoods Program, the study population consists of N=818 children aged 0≤11 years old (N=409 at baseline and N=409 at follow-up) and N=818 youngsters aged 12≤18 years old (N=409 at baseline and N=409 at follow-up), living in the selected intervention and control neighbourhoods in Rotterdam.

## Data collection/outcomes

The data collection that will be performed for this evaluation study is discussed separately for each stage of the logic model. The baseline measurement takes place from November 2018 to February 2019. Implementation of the Promising Neighbourhoods program in the intervention neighbourhoods will take place from February 2019 onwards, after the baseline measurement. The follow-up measurement will take place from September 2020 to March 2021.

### *Assets*

Data regarding the assets (knowledge and expertise of community stakeholders about the neighbourhood such as existing problems, municipal support, support from partners, sponsors, and target groups, willingness to collaborate in the Promising Neighbourhoods program, and collaboration and coordination in the neighbourhood) will be studied among community stakeholders in all participating neighbourhoods

**Table 1** Overview of evaluation measurements.

| Logic model | Indicators | Measures | Study population/data | Time point | |
|---|---|---|---|---|---|
| **Process-implementation evaluation** | | | | **T0** | **T1** |
| Assets | knowledge and expertise among community stakeholders in the neighbourhood, support from sponsors, willingness to collaborate in a CCP approach, use of interventions[a], collaboration & coordination in the neighbourhood, financial and municipal resources | online-questionnaire, focus groups, registration data | community stakeholders, youngsters, municipality of Rotterdam | **X** | **X** |
| Input | existing problems in the neighbourhood, effectiveness of community coalitions, decision-making process, existing interventions in the neighbourhood, interventions[a] proposed by community stakeholders, quality of interventions[a], quality of the intervention-package of the CCP approach | online-questionnaire, focus groups, registration data | community stakeholders, youngsters, municipality of Rotterdam | **X** | **X** |
| Output | actual implemented interventions[a], quality of and collaboration of coalitions among community stakeholders, organizations, increase in assets, costs, type, quality, frequency, intensity, reach of interventions[a], characteristics of the reached groups, use of effective programs, monitoring of implementation and effects | registration data, questionnaire | municipality of Rotterdam, key-leaders | **X** | **X** |



using an anonymous online-questionnaire and focus groups (see table 1). This online-questionnaire is based on an instrument (Community Board Interview) to collect information about community stakeholders in neighbourhoods and their role in the process-implementation and their characteristics (19). This instrument was used for evaluation of the CtC approach in the USA, the Netherlands, and Germany (17, 20, 40) and will be adapted for this process-implementation evaluation of Promising Neighbourhoods. The questionnaire will take at most 30 minutes to fill out and will be administered from November 2018 to February 2019 and from September 2020 to March 2021**.** Subsequently, focus groups addressing the assets will be organized from November 2018 to February

**Table 1** Overview of evaluation measurements. (Continued)

| Logic model | Indicators | Measures | Study population/data | Time point | |
|---|---|---|---|---|---|
| **Effect evaluation** | | | | | |
| Intermediate outcomes | indicators of: family environment (parenting, child-parent relationship, family life, family conflict), healthy exercise and nutrition behaviours, smoking and substance use, social cohesion, use of facilities and care, bullying | Health survey (baseline/ similar questionnaire follow-up), You and Your Health (third grade) or SDQ (first grade) | children aged 0≤11 years old, youngsters aged 12≤18 years old | **X** | **X** |
| Ultimate outcomes | indicators of: health (socio-emotional and/or psychological problems, general (physical) health, overweight), safety: (home environment, neighbourhood), and talent development: (school performance, truancy) | Health survey (baseline/ similar questionnaire follow-up), You and Your Health (third grade) or SDQ (first grade), routinely collected data | children aged 0≤11 years old, youngsters aged 12≤18 years old, municipality of Rotterdam | **X** | **X** |
| Covariates | age, sex, ethnicity, and socioeconomic status indicators: (educational level of the parents when children are at age 0≤11, educational level of the youngster 12≤18) | Health survey (baseline/ similar questionnaire follow-up), You and Your Health (third grade) or SDQ (first grade), routinely collected data | children aged 0≤11 years old, youngsters aged 12≤18 years old, municipality of Rotterdam | **X** | **X** |

Overview of indicators, measures, instruments, study population, source of data and measurement moments in the study following the stages of the logic model. Abbreviations: CCP: Collaborative community program; SDQ: Strengths and Difficulties Questionnaire.[a] Also includes measures, facilities and activities.

2019 and from September 2020 to March 2021 in each neighbourhood. In total, there will be six focus groups at baseline and six focus groups at follow-up. Additionally, two focus groups among youngsters (aged 12≤18 years old) will be organized, both at baseline and at follow-up; one group representing the intervention neighbourhoods and one group representing the control neighbourhoods. The same topics regarding the assets will be addressed. The focus groups among youngsters are specifically used to take the perspective of youngsters about the quality of neighbourhood conditions into account.

To assess financial resources, we will use registration data of the municipality of Rotterdam.

*Input*

Data regarding the input (effectiveness of neighbourhood networks consisting of community stakeholders in the neighbourhood, and existing measures, plans, interventions, facilities and activities) will be studied using the same online-questionnaire and focus groups in 2018/2019 and 2020/2021 as will be used to study the assets (see table 1). The anonymous online-questionnaire and focus groups will be held among community stakeholders in all participating intervention and control neighbourhoods. Additionally, in the two focus groups among youngsters representing the intervention neighbourhoods and youngsters representing the control neighbourhoods (aged 12≤18 years old) the same topics regarding the input will be discussed. To assess existing measures, interventions, facilities and activities in the neighbourhood, we will use registration data of the municipality of Rotterdam and additional surveys of key-leaders.

*Output*

Data regarding the output (costs, type, number, quality, frequency, intensity, reach and characteristics of the reached groups of the implemented measures, interventions, facilities, and activities, use of a knowledge/science-based approach, use of effective programs and monitoring of implementation) will be studied using a questionnaire (see table 1). This questionnaire will be administered among key-leaders in November 2018 to February 2019 and from September 2020 to March 2021. This questionnaire is an adapted version of the Key-Informant questionnaire previously used in CtC evaluations in the USA, the Netherlands and Germany (17, 22). This questionnaire will take at most 60 minutes to fill out and will be administered via telephone. During the focus groups with community stakeholders in 2020/2021, and the online-questionnaire prior to it, the contribution of assets and input to the realized output will be discussed. To examine the costs, type, number, quality, frequency, intensity, reach and characteristics of the reached groups of the implemented measures, interventions, facilities, and activities we will use registration data of the municipality of Rotterdam. These data are registered by the municipal district advisors and providers of the interventions (see table 1).

*Intermediate outcomes*

In this study, the intermediate outcomes are the proximal results of the measures, interventions, facilities and activities that will be implemented in the neighbourhoods. Therefore, we will study indicators of the following targeted risk and protective factors among children and youngsters: family environment (parenting, child-parent relationship, family life, and family conflict), healthy exercise, nutrition behaviours, smoking

and substance use, social cohesion, use of facilities and care, and bullying (see table 1). Data on intermediate outcomes will be collected at two time points, in 2018 at baseline and in 2020/2021 at follow-up, separately for children aged 0≤11 years old and for youngsters aged 12≤18 years old.

For the baseline measurement of intermediate outcomes among 0≤11 years old children, we will use anonymous survey data from the Health survey obtained in 2018 by the municipality of Rotterdam. The Health survey is administered every four years in a random sample drawn from the municipal population register using online parent-questionnaires. The Health survey consists of questionnaires addressing the following topics: general health, nutrition and exercise behaviour, home-environment, emotional and psychological health, neighbourhood-, and school environment, use of care and facilities, smoking and alcohol (39). Follow-up data will be collected by administering a comparable parent-questionnaire for children aged 0≤11 years old in 2020/2021. This questionnaire will be based on the Health survey and will include similar questions. We will use the same procedures for sample selection and administration of the follow-up questionnaire, as used by the municipality for the Health survey (the baseline data).

For the baseline and follow-up measurements in the group of 12≤18 years old youngsters we will use survey-data obtained by the Child and Family Centre Rijnmond in 2018 and 2020/2021 respectively. These survey data consist of the SDQ and the so-called You and Your health questionnaire which includes several validated questionnaires (39, 41-43). The You and Your health questionnaire addresses the following topics: general health, nutrition and exercise behaviour, home-environment, emotional and psychological health, school environment, performing anxiety and learning behaviour, smoking, alcohol, substance use and gaming. These questionnaires are routinely administered by the Child and Family Centre Rijnmond every year for municipal health monitoring. The questionnaires are filled out online at school, the SDQ in first grade and You and your Health in third grade.

***Ultimate outcomes***

Ultimate outcome measures are: indicators of health (socio-emotional and/or psychological problems, general/physical health, overweight), safety (safety of the home environment, safety of the neighbourhood) and talent development (school performance, truancy) (see table 1). Ultimate outcomes will be collected at the same two time-points, at baseline and at follow-up after implementation of the Promising Neighbourhoods program. The same instruments as for the intermediate outcomes will be used, separately for children aged 0≤11 years old and for youngsters aged 12≤18 years old. Since truancy, school performance and safety in the neighbourhood are not administered by

the Health survey, SDQ or You and Your Health questionnaire we will use routinely collected data on the individual, school and neighbourhood level from the municipality of Rotterdam for these outcomes.

*Covariates*

In addition to the intermediate and ultimate outcomes, demographical data including neighbourhood, age, sex, ethnicity, and socioeconomic status will be collected for the effect evaluation. Socioeconomic status will be measured as the highest educational level obtained either by both parents or the mother for children aged 0≤11 years old and current educational level of youngsters aged 12≤18 years old. Educational level will be classified according to the International Standard Classification of Education 2011 (44). Demographical data will be obtained from the municipality of Rotterdam and the Child and Family Centre Rijnmond.

## Power considerations

The size of the data samples needed to determine small-effect sizes (f2=0.02) is calculated for the effect evaluation (45). Analyses will be performed separately for children aged 0≤11 years old and for youngsters aged 12≤18 years old as outcome-variables of interest might differ between age groups and are measured in a different way. Based upon 5% two-sided significance tests of the null hypothesis that socioeconomic status-groups in the intervention and control neighbourhoods do not differ on outcome variables at follow-up and a power of 80% allowing for 10 independent variables in the model, we need two samples of 818 individuals, one sample including children aged 0≤11 years old and one sample including youngsters aged 12≤18 years old. Half of each sample will consist of individuals at baseline, evenly distributed over the conditions (intervention or control neighbourhood). The other half will consist of individuals at follow-up, evenly distributed over conditions as well. For the baseline measurement of both age groups, we will have sufficient survey data. For the follow-up measurement of youngsters aged 12≤18 years old sufficient survey data is available because the Child and Family Centre Rijnmond administers their survey every year. However, since the Health survey of the municipality of Rotterdam is administered only once every four years we will not have sufficient follow-up data for children aged of 0≤11 years old. Therefore, we will gather these data by administering an additional comparable parent-questionnaire. With a predicted response rate of 40% we will need to reach 1025 parents in order to receive 409 follow-up questionnaires.

## Data analyses

The process-implementation evaluation consists of the assets, input and output stages in the logic model. All focus groups and questionnaires will be documented and analysed

using standardized formats. The qualitative data will be analysed using a set of codes. At the start of the analysis, a codebook will be made with herein a list of pre-set codes on different levels such as concepts or categories. This codebook will be made by two researchers independently coding the first two focus groups. During the analysis new codes may occur. These codes will be added to the codebook. Questionnaire data and register-data per intervention and per neighbourhood about the costs, type, number, quality, frequency, intensity, reach, and characteristics of the reached groups will also be analysed to detect changes between the baseline measurement and the follow-up measurement. Intervention and control neighbourhood results will be compared. Because of the relative small size of the groups in the process-implementation evaluation, T-tests with Bayesian statistics will be used (46, 47). This will be performed using the program Jags in R. Intervention and control estimates will be compared, each chain with 5,000 iterations and each time 500 not used. At the end, the estimates will be made with a total of 4,500 estimates.

In the effect evaluation of the Promising Neighbourhoods program, effects on the dependent intermediate outcomes (indicators of risk and protective factors) and ultimate outcomes (indicators of health, safety and talent development) of the logic model will be examined. We will perform Difference-in-Difference regression analyses separately for children aged 0≤11 years old and for youngsters aged 12≤18 years old. Predictor variables of interest are time of measurement (baseline/follow-up), condition (intervention/control), socioeconomic status, and their two-way and three-way interactions controlled for neighbourhood conditions. We will also adjust for other sociodemographic covariates. The main variable of interest in our study is the three-way interaction term for time of measurement, condition, and socioeconomic status. A significant parameter ($p<0.05$) for this interaction term indicates a change in outcome over time in the intervention neighbourhoods with a socioeconomic status gradient. In case of continuous outcome variables linear regression analysis will be used and for dichotomous outcome variables logic regression analysis will be used. Missing data will be handled using multiple imputation. Level of significance is set at 0.05 for two-tailed analyses.

## DISCUSSION

This article describes the design and methodology of a mixed-methods study for evaluation of the process-implementation and effectiveness of the Promising Neighbourhoods program. Promising Neighbourhoods is a program aiming to reduce socioeconomic health inequalities and to increase health, safety and talent development among youth

in different neighbourhoods of Rotterdam. The Promising Neighbourhoods program will be gradually implemented in all neighbourhoods in Rotterdam, if proven effective.

We hypothesise that a collaborative community programming approach with stakeholders leads to clear priority setting and better tailored interventions of better quality. Furthermore, we hypothesise a decline in socioeconomic inequalities in intermediate and ultimate outcomes for health, safety and talent development in intervention neighbourhoods in comparison to control neighbourhoods. As we also study the process-implementation of the Promising Neighbourhoods program, we will be able to provide relevant insights on possible facilitators and barriers for future implementation of policy programs using a collaborative community approach, such as Promising Neighbourhoods.

A strength of this study is that we study the process-implementation as well as the effectiveness (48). Without evaluation of the process-implementation, the black box of why a program is effective or not effective cannot be disentangled (48). Furthermore, the process-implementation evaluation can also shed light on possible defects or unwanted side effects within the Promising Neighbourhoods program (10). Adding to this, it may elucidate how to successfully adapt programs and reach specific communities. Therefore, this study is relevant for local settings and collaborative programming and for national governments that depend on successful local implementation of policies. Another strong aspect is that we evaluate the process-implementation and effectiveness in different neighbourhoods increasing the generalisability of our findings.

The limitations that need to be taken into consideration are first that long term effects are not part of our study design. The time of two years between the baseline and follow-up does not allow studying longer term outcomes on especially the intended ultimate outcomes in the current study. Second, there is always a chance for residual confounding even though we will adjust for confounding in our analyses and tried to match intervention neighbourhoods as much as possible based on the degree of experienced problems and on socioeconomic status. We cannot control planned or unplanned implementation of interventions in the neighbourhoods on the initiative of other institutions or in some cases even of collaborating community stakeholders. Moreover, we cannot control for the fact that children, youngsters and their families in control neighbourhoods may receive or take part in interventions or activities provided in the intervention neighbourhoods. Or that they take part in interventions or activities implemented independently of interventions that are part of the Promising Neighbourhoods program. However, to monitor this, we will obtain registration data about implemented measures, interventions, facilities and activities in the neighbourhoods.

In conclusion, this study will provide knowledge about the process-implementation and effectiveness of a collaborative community programming approach implemented together with stakeholders, using data-based priority setting, knowledge-, and theory-based policies and evidence-based interventions. The results following from this study may be used for the design, implementation and transferability of intervention programs aiming to reduce health inequalities among youth using a collaborative community programming approach with stakeholders. Therefore, our study is relevant for local and national public health authorities and for improvement of the health, safety, and talent development among youth.

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# 9

# Effectiveness of the Promising Neighbourhoods community program in 0-to 12-year-olds

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## ABSTRACT

**Objective:** The purpose of this study was to evaluate a collaborative community-based program that aims to a) increase the health, safety and talent development of youth, and b) contribute to the reduction of socioeconomic inequalities.

**Methods:** A quasi-experimental difference-in difference design with two separate cross-sectional samples among 0- to 12 year-olds with an intervention and control condition was used. Measurements took place with baseline measurements in 2018 (N=984) and follow-up measurements in 2021 (N=413). The program, called Promising Neighbourhoods, consists of collaboration with community stakeholders, data-based priority setting, knowledge-and theory-based policies, and evidence-based interventions. The program was implemented in three neighbourhoods which were matched to three similar control neighbourhoods. Logistic difference-in-difference regression was used to test effectiveness of the intervention on informal parenting support, outdoor-play, sport club membership, general health and risk of mental health problems and to examine differences in intervention effects between children with a lower or higher socioeconomic status.

**Results:** A significant intervention effect of the Promising Neighbourhoods program after two-years was found for outdoor-play (OR 0.61; 95%CI 0.37, 0.99). No other significant intervention effects were found for other outcomes. No different interventions effects were found for children with a lower or higher socioeconomic status on outcomes.

**Conclusion:** The findings of this study indicate a positive intervention effect for one of the outcomes in 0- to 12-year-olds. Further mixed-methods evaluation research and using longer follow-up periods are needed to examine the value of these type of programs. Further development of Promising Neighbourhoods seems warranted.

**Trial registration:** This study was prospectively registered in the Netherlands National Trial Register (Number: NL7279) on 26 September 2018.

## INTRODUCTION

Socioeconomic status (SES) influences the development and health of youth.(1, 2) Socioeconomic inequalities already arise in the youngest age groups and often continue in adult life.(3-5) Therefore, investing in reducing socioeconomic inequalities in children is important.(6) Yet, much research has been performed on the magnitude and causes of socioeconomic inequalities but relatively less on effective approaches to reduce them. (6, 7)

The Ottawa Charter already mentioned in 1986 that community involvement and creating supportive conditions and environments could be strategies to reduce inequalities and to increase health and well-being of the community.(8, 9) Intersectoral collaboration and interorganizational partnerships (e.g. governmental and non-governmental organizations and stakeholders), community participation and engagement in planning and decision-making (e.g. stakeholders), creating healthy settings, political commitment, funding and infrastructure for social policies, employing multiple strategies and actions at multiple levels and sectors and awareness of the socio-environmental context were found to be key actions central to the effectiveness of health promotion programs. (10, 11)

Local governments can play an important role in reducing inequalities and promoting the health, safety and talent development of children as they have a responsibility for the planning and delivery of services such as education, transport, housing and urban planning.(12) Moreover, local governments are often in a strong position to bring a wide variety of local actors or stakeholders around the table to stimulate action.(12) In the past years there has been an increasing focus on local integrated community-based programming approaches.(13) Collaborative community-based approaches employ multiple interventions, involve key-leaders and networks, and aim to strengthen the community.(14) As collaborative community-based programs comprise many of the key actions mentioned above, they are regarded as promising in reducing socioeconomic inequalities in health, safety and talent development in youth.(14-16)

One previous community-based program that focused on reducing socioeconomic inequalities is the EPODE-program for the Promotion of Health Equity (EPHE).(17, 18) In this program communities developed and implemented tailored lifestyle interventions to the needs of the specific socioeconomic groups.(17, 18) The EPHE-program was successful in changing behaviour of children with a lower SES as well as changing the behaviour of children with a higher SES.(17) Communities that Care (CTC) is another collaborative community-based program that aimed to reduce problem behaviour

among children and adolescents. CTC was implemented at the neighbourhood level. Professionals in these neighbourhoods formed community coalitions, performed a needs assessment and chose which interventions needed to be implemented. CTC reduced health-risk behaviour in the United States of America.(19-22) In the United Kingdom and the Netherlands results were less favourable.(23-26) Recently, also CTC in Australia led to reduced health-risking behaviour in adolescents.(27, 28) Results of these programs indicate that, indeed, community engagement and tailored programs could be promising. More research is needed to increase the evidence-base on community-based programs.

The Promising Neighbourhoods collaborative community-based program partly builds on experience of earlier methodologies such as CTC and the EPODE-program.(17, 29) The program was developed by the municipality of Rotterdam in collaboration with the Netherlands Youth Institute (NYI) with the aim to increase the health, safety and talent development of youth living in Rotterdam, and to contribute to the reduction of socioeconomic inequalities, as a part of a wider youth policy program called "Rotterdam Grows".(30) The Promising Neighbourhoods program consists of collaborating with community stakeholders, data-based priority setting, knowledge-and theory-based policies, and evidence-based interventions.(31) The results of the effect evaluation of this program on health outcomes and on health inequalities in 0-to 12-year olds are described here.

## Research questions

1: What is the effectiveness of the Promising Neighbourhoods program in 0- to 12-year-olds on health outcomes (informal parenting support, outdoor-play sport club membership, general health and risk of mental health problems)?

2: What is the effectiveness of the Promising Neighbourhoods program in 0-to 12-year-olds on reducing socioeconomic inequalities in these health outcomes?

## Study hypothesis

We hypothesize that the Promising Neighbourhoods program leads to improved health outcomes and to reduced socioeconomic inequalities on these outcomes.

## METHODS

### Study design

The study design has been described elsewhere.(31) Briefly, this study utilizes a quasi-experimental difference-in difference design with two separate cross-sectional samples with an intervention and control condition. Measurements took place before implementation at baseline (T0) between May-July 2018 and at follow-up after implementation (T1) between April-July 2021.

This study was prospectively registered in the Netherlands National Trial Register (Number: NL7279) on 26 September 2018.

### Setting

The setting has been described in a protocol paper for this study.(31) Briefly, to ensure a sufficient range of problems and diversity of neighbourhood SES, neighbourhoods were categorized as low, middle or high degree of problems. From each category an intervention neighbourhood was selected resulting in three intervention neighbourhoods and matched to control neighbourhoods from the same category. One control neighbourhood decided to implement common programming comparable to the Promising Neighbourhoods program on its own. Therefore, one new control neighbourhood was matched to one intervention neighbourhood. The control neighbourhood that started with the common programming is used in the sensitivity analyses for comparison.

### Study population

Data of 984 children aged 0-to 12-years old and were available at baseline and 413 at follow-up. Within this sample, respectively, 649 and 268 were 4-to 12-year-olds.

Invitations to participate were done by drawing a random probability sample from the municipal population register stratified by neighbourhood. Children living in a healthcare institution were excluded. Parents received invitations for one child only. All parents were living in Rotterdam when the survey was administered. At baseline the response rate for 0-4-year olds was 41.0% and for 4-12-year olds the response rate was 38.0%. At follow-up the response rate for 0-4 year olds was 37.0% and for 4-12-year olds the response rate was 31.8%.

A power calculation to determine the sample size of the data needed to determine small effect sizes (f2=0.02) has been previously described.(31, 32) A sample of 818 (409 at baseline and 409 at follow-up) evenly distributed over the intervention and control neighbourhoods would provide sufficient power.

## The Promising Neighbourhoods program

The collaborative community-based program has been described extensively in the study protocol.(31) Briefly, the aims of the program are to increase the health, safety and talent development of youth.(30) The program is a collaborative community-based approach that includes community stakeholders, works with data-driven priority setting, knowledge- and theory-based policies and focuses on implementation of evidence-based interventions.(17, 29) This program is continuously further developed and adjusted. Also during this study the program was further developed. The programs is seen as a learning process.

The program is managed by municipal district advisors.(33) Each municipal district advisor is assigned to a different neighbourhood and coordinates and monitors the program. Together with community stakeholders and key-leaders from the neighbourhood network the municipal district advisor plans and develops a tailored intervention package for the neighbourhood. This package can consist of parenting support, preventive (health) interventions, youth welfare, preventive measures and activities to improve preventive health, safety and talent development among youth.

The program consists of multiple steps.(33) Step 1 is a needs-assessment of the neighbourhood based on local quantitative registry and survey data. In step 2, the needs-assessment is discussed with the neighbourhood network to match the conclusions with qualitative insights based on their daily experiences and to gain local support by setting joint goals. In step 3, the needs-assessment is adapted based on the insights from step 2. Based on this assessment priorities for the neighbourhood are determined (data based-priority setting). Table 1 shows the priorities that have been set for the intervention neighbourhoods. In step 4, municipal district advisors and the neighbourhood network inventoried the current interventions, policy measures, actions and agreements in the neighbourhood and checked the evidence-base of the intervention in the database of Effective Youth Interventions of the NYI(https://www.nji.nl/nl/Databank/Databank-Effectieve-Jeugdinterventies). In step 5, the most appropriate and available interventions, policy measures, actions and agreements for the priorities are chosen by the municipal district advisors and neighbourhood network. A detailed neighbourhood intervention-package plan including the needs-assessment, priorities and policy measures, interventions and activities is developed in step 6. Table 1 shows the interventions, policy measures, actions and agreements that have been chosen in the intervention neighbourhoods for youth aged 0-18 year old. In step 7, this plan is implemented in the neighbourhood. Step 8 consists of continuous monitoring and evaluation.

**Table 1.** Overview of the priorities, interventions and policy measures, actions and agreements in intervention neighbourhoods for children aged 0- to 18-years old.

| Priorities | Interventions | Policy measures, actions and agreements among partners |
|---|---|---|
| 1) More children have better social-emotional health<br>2) Reduced risk of psychosocial problems<br>3) Reduced problem behaviour of the child<br>4) Fewer children are anxious<br>5) Fewer children are bullied<br>6) 50% of all children participate in a training for social emotional development as part of the school curriculum<br>7) More children are playing outside<br>8) An increase of children that participate in sports after school<br>9) More children have a better general health<br>10) More parents have informal parenting support<br>11) An increase in children that grow up in a save home environment<br>12) More young people perform better at school and obtain their school diploma<br>13) Reduced relative school absence<br>14) The burden of crowd forming / hanging out on the streets among older youth is diminishing<br>15) A decrease in youth criminality | -4 interventions for 0-4 year olds, mainly focused on parenting skills and socio- emotional skills<br>-10 interventions for primary school-aged children mainly focused on parenting skills, low SES and/or social emotional skills<br>-3 interventions focused on children of divorced parents<br>-4 interventions focused on children with parents who suffer from psychiatric problems or addiction<br>-7 interventions for youth from 12-25 mainly focused on socio-emotional skills<br>-16 interventions for parents mainly focused at parenting skills<br>-2 interventions focused on domestic violence and fights at home<br>-6 intervention only given at primary school focused at socio-emotional skills and resilience<br>-1 intervention only given at secondary school focused at socio-emotional skills and resilience<br>-2 intervention focused on delinquency and safety<br>-2 interventions focused on participation<br>-1 Intervention focused on poverty and debts<br><br>Total = 57 interventions of which 3 interventions fell in two categories | 1) Training teachers on social emotional development.<br>2) Improving collaboration and awareness and knowledge of preventive interventions on social emotional skills between schools and other partners.<br>3) Improving knowledge and awareness of parents and professionals about alcohol and drug use during pregnancy and parenthood.<br>4) Improve parenting skills, healthy lifestyles and reduce risk behavior of children by providing more information to parents.<br>5) Implementing media classes as schools.<br>6) Actively promoting the pedagogical neighbourhood values at school and in the neighbourhood.<br>7) Square/playground programming on the various squares/playgrounds.<br>8) Improve early identification of conduct problems.<br>9) Focus on pregnant women and young families in collaboration with partners in neighbourhood.<br>10) Increase sport participation among primary school aged children by increasing the opportunities for sport through sport clinics, by increasing awareness on sport facilities, and by increasing accessibility.<br>11) Stimulate children to participate in sport, culture or side jobs using role models, by offering locations, offering work-learning trajectories, offering side jobs, and organizing activities for and with youth and training in language improvement for parents and children.<br>12) Reducing poverty and debt by increasing the reach of a debt-reduction program and by subsidies for sport and other activities using municipal funds.<br>13) Improved collaboration of schools with truant officers, police officers and social welfare teams to reduce school absenteeism and delinquency.<br>14) Good and sufficient homework guidance through, among other things, the use of community centers.<br>15) Improve collaboration between youth workers.<br>16) Expand collaboration among care and support professionals in the neighbourhood (general practitioners, physiotherapists, dietiticans, etc) and schools.<br>17) Aligning the attention from neighbourhood network partners to language improvement.<br>18) Discuss approach for pupils that live in other neighbourhoods with higher problem levels. |

The priorities differed between intervention neighbourhoods. Interventions, policy measures, actions and agreements differed between the intervention neighbourhoods.

## Control neighbourhoods

In the control neighbourhoods no collaborative community-based program (Promising Neighbourhoods program) was implemented. Interventions, policy measures and actions have occurred as usual. The city of Rotterdam provides resources for a selected group of interventions that could be provided at city or neighbourhood level. These interventions can include but are not limited to parenting support, socio-emotional skills training, and interventions for children of parents with a mental illness or addiction.

## Data collection

The baseline measurement was derived from data gathered in 2018 using a Dutch public health survey administered by the municipal public health service in the city of Rotterdam. Data for the follow-up measurement were gathered separately in 2021 using a similar survey and approach. Both surveys targeted parents/caretakers of 0-12-year old children. Questionnaires were filled out by the main caregiver.

Parents received hardcopy invitation letters with information about the online survey and login details. Hardcopy questionnaires were sent with the first reminder. The questionnaires were available in Dutch, English and Turkish. Non-responders were contacted by telephone and were offered extra help in completing the questionnaire. Small incentives were used for both measurements.

## Ethics

The medical ethics committee of the Erasmus University Medical Center Rotterdam declared the Medical Research Involving Human Subjects Act does not apply and issued a declaration of no objection for this study (MEC-2018-1506). Parents received information about the study and could refuse participation by not filling out the survey.

## Measures

The outcome measures were collected using the surveys at baseline and follow-up. Three outcome measures were measured in 0-12-year olds (informal parenting support, outdoor-play and general health) and two in 4-12-year olds (sport club membership and risk of mental health problems (MHP). Subscales and subscale items reflecting the priorities that were set for the intervention neighbourhoods were additionally explored.



***Outcome measures in 0- to 12-year-olds***

*Informal parenting support* – Informal parenting support was measured by the item: 'Can you talk to your family, friends, acquaintances or neighbours about (problems with) raising your child?' Answer categories were: Yes often, Yes regularly, Yes occasionally

or No hardly ever or never. This was dichotomized as 'Yes' (Yes often, Yes regularly) and 'No' (Yes occasionally, No hardly ever, never). The first category was used as reference.

*Outdoor-play* – Outdoor-play was measured by two items. The first item was: 'On how many days per week does your child play outdoors? " Answer categories were: My child did not play outdoors last week, but would usually do that in an ordinary week, never, 1, 2, 3, 4, 5, 6 or every day. The second item assessed the time their child usually spends playing outdoors. Answer categories were: Less than half an hour per day, half an hour to an hour per day, 1-2 hours per day, 2-3 hours per day or 3 hours per day or longer. For both questions we asked parents to base their answer on the past week. We dichotomized these questions to: 'Outdoor-play for ≥60 minutes for ≥5 days a week' or 'No'. The first category was used as reference.

*General health* – General health was measured by the item 'How would you describe your child's general health' (Very good, good, alright, not very good or poor); this was dichotomized as 'good' (very good, good, alright) or 'poor'.

***Outcome measures in 4- to 12-year-olds***

*Sport club membership* – Sport club membership was measured by the item 'How many days per week does your child sports with a club'. Parents were asked to base their answer on the past week. Answer categories were: never, my child did not do any sports last week, but would usually do that in an ordinary week, 1, 2, 3, 4, 5, 6, or every day. This was dichotomized as 'sports at a sport club for ≥1 day a week' or 'No'. The first category was used as the reference.

*Risk of mental health problems (MHP)* – Risk of MHP was measured using the SDQ which was embedded in the surveys. This is a validated questionnaire to measure risk of mental health problems and consists of five subscales: emotional problems, conduct problems, hyperactivity, peer-problems and prosocial behavior.(34-36) We calculated the total difficulties score by adding the scores of all domains except for prosocial behavior (Cronbach's alpha=0.75). We dichotomized the total difficulties score using age dependent cut-offs to either 'Normal score' or 'High risk' with the normal score as reference category. For 4-7-year olds a cut-off of ≥15 and for 7-12-year olds a cut-off of ≥14 indicates risk of MHP.(34-36)

Several subscales and scale items were additionally explored. The subscale emotional problems (Cronbach's alpha=0.67) consists of five items about somatic symptoms, worries, feeling unhappy, being nervous in new situations and being anxious. The subscale

conduct problems (Cronbach's alpha=0.50) consists of five items about tantrums, obeying, bullying, lying, and stealing. Answer categories were: Not true, somewhat true, or certainly true. We computed subscale scores by adding the scores of all five items. We dichotomized these scores using age dependent cut-offs to either 'Normal score' or 'High risk' with the normal score as reference category. A score of 4-10 indicates emotional problems. A score of 3-10 indicates conduct problems.(34-36) We also used the following individual items: anxiety from the subscale emotional problems, tantrums, bullying, and stealing from the subscale conduct problems and being bullied from the peer-problem subscale. These were dichotomized as 'No'(Not true) or 'Yes' (Somewhat true, certainly true) with the first category as reference.

## Covariates

### *Sociodemographic measures*

Age was measured continuously in years. Gender was measured as *'boys'* or '*girls'* using the first as reference category.

### *Socioeconomic status (SES)*

Parental educational level was used as indication of SES and was defined as highest parental educational level obtained and categorized as *'higher'* (higher vocational training, university degree, or higher) or *'lower and intermediate'* (no education, primary school, ≤4 years general secondary school, >4 years general secondary school or intermediate vocational training).(37) The first category was the reference category.

## Statistical analysis

Participant characteristics and health outcomes were described at baseline and at follow-up for the intervention and control neighbourhoods. Differences were tested using chi-square or Mann-Whitney U tests ($p < 0.05$).

Multiple imputation (m=5) using a fully conditional specified model based on the relationships between the variables included in this study was used for missing values. Multiple imputation was performed for variables measured for 0-12-year olds (2.1% missing values) and for variables measured for 4-12-year olds (0.6% missing values).

Logistic difference-in-difference regression analysis was used to test intervention effects for the outcomes as well as differences in intervention effects according to SES. For the difference-in-difference regression analyses we computed two models.

In the first model we examined the intervention effect. The coefficient β3 of the interaction term between the condition (intervention or control) and time of measurement (baseline or follow-up) depicts the intervention effect on the outcome. We adjusted for SES, gender and age. This model can be written as:

$\gamma = \beta 0 + \beta 1 * \text{time of measurement} + \beta 2 * \text{condition} + \beta 3 * \text{time of measurement} * \text{condition} + C\ (\text{SES, gender and age})$

The second model examined if the intervention effect differed according to SES. A three-way interaction between time of measurement, condition and SES was added and all possible underlying two-way interactions. We also adjusted for age and gender. In this model β7 is the key-parameter. This model can be written as:

$\gamma = \beta 0 + \beta 1 * \text{time of measurement} + \beta 2 * \text{condition} + \beta 3 * \text{SES} + \beta 4 * \text{time of measurement} * \text{condition} + \beta 5 * \text{time of measurement} * \text{SES} + \beta 6 * \text{condition} * \text{SES} + \beta 7 * \text{time of measurement} * \text{condition} * \text{SES} + C\ (\text{age, gender})$

Pooled effect estimates (odds ratios [ORs] and 95% confidence intervals [CIs]) from these five datasets were reported. Two-sided p-values denoted statistical significance ($p<0.05$).

Exploratory analyses were performed in the multiple imputed data in a similar way. We repeated our analyses using a complete-case dataset. As one control neighborhood was replaced at the beginning of the study, we did a sensitivity analysis with the replaced neighbourhood instead of the new control neighbourhood.

IBM SPSS statistics for Windows, version 25.0 (International Business Machines Corporation, Armonk, New York) was used for all analyses.

## RESULTS

Table 2 shows the characteristics of the study population (Supplemental table 1 includes missing values). At baseline, children in control neighbourhoods were on average older than children in intervention neighbourhoods. Over time, significantly more parents received informal parenting support in both control and intervention neighbourhoods. Outdoor-play significantly reduced over time in control neighbourhoods and increased in intervention neighbourhoods.

**Table 2.** Characteristics of the intervention and control neighbourhoods at baseline in 2018 and in 2021.

| | 2018 (n=984) | | 2021 (n=413) | |
|---|---|---|---|---|
| | **Control neighbourhoods (n=427; 43.4%)** | **Intervention neighbourhoods (n=557; 56.6%)** | **Control neighbourhoods (n=170; 41.2%)** | **Intervention neighbourhoods (n=243; 58.8%)** |
| **Sociodemographic variables** | | | | |
| Age, continuous [a] | 6.0 (3.0-9.0) | 5.0 (2.0 (8.0) | 6.0 (2.8-9.0) | 5.0 (2.0-9.0) |
| Age, dichotomous [a] | | | | |
| 0-4 | 137 (31.2%) | 210 (37.7%) | 59 (34.7%) | 85 (35.1%) |
| 4-12 | 302 (68.8%) | 347 (62.3%) | 111 (65.3%) | 157 (64.9%) |
| Gender | | | | |
| *Boy* | 216 (50.6%) | 276 (49.6%) | 81 (47.9%) | 116 (47.7%) |
| *Girl* | 211 (49.4%) | 281 (50.4%) | 88 (52.1%) | 127 (52.3%) |
| **SES** | | | | |
| Parental education | | | | |
| *Higher* | 228 (55.6%) | 276 (51.3%) | 104 (61.9%) | 134 (56.3%) |
| *Lower and intermediate* | 182 (44.4%) | 262 (48.7%) | 64 (38.1%) | 104 (43.7%) |
| **Outcomes in 0 to -12-year-olds** | | | | |
| Informal parenting support [b,c] | | | | |
| *Yes* | 238 (56.3%) | 340 (61.4%) | 118 (69.8%) | 171 (70.7%) |
| *No* | 185 (43.7%) | 214 (38.6%) | 51 (30.2%) | 71 (29.3%) |
| Outdoor-play [b,c] | | | | |
| *Yes* | 168 (41.6%) | 232 (45.1%) | 49 (31.0%) | 103 (45.8%) |
| *No* | 236 (58.4%) | 282 (54.9%) | 109 (69.0%) | 122 (54.2%) |
| General health | | | | |
| *Good* | 389 (92.0%) | 509 (91.5%) | 163 (95.9%) | 227 (93.4%) |
| *Not Good* | 34 (8.0%) | 47 (8.5%) | 7 (4.1%) | 16 (6.6%) |
| **Outcomes in 4- to -12-year-olds** | | | | |
| Sport club membership | | | | |
| *Yes* | 164 (56.7%) | 190 (55.6%) | 65 (59.1%) | 80 (51.6%) |
| *No* | 125 (43.3%) | 152 (44.4%) | 45 (40.9%) | 75 (48.4%) |
| Risk of mental health problems | | | | |
| *No* | 257 (88.9%) | 302 (88.8%) | 102 (92.7%) | 135 (87.1%) |
| *Yes* | 32 (11.1%) | 38 (11.2%) | 9 (7.3%) | 20 (12.9%) |

P-values computed using chi-square for categorical variables and Mann Whitney U tests for continuous variables.

[a] Indicates a significant difference between intervention and control neighbourhoods in 2018 (p-value <0.05).

[b] Indicates a significant difference between control neighbourhoods in 2018 and control neighbourhoods in 2021 (p-value <0.05).

[c] Indicates a significant difference between intervention neighbourhoods in 2018 and intervention neighbourhoods in 2021 (p-value <0.05).

**Table 3.** Difference-in-Difference logistic regression analyses.

| | **Informal parenting support 0- to 12-year-olds** | **Outdoor-play 0- to 12-year-olds** | **General health 0- to 12-year-olds** | **Sport club membership 4- to 12-year-olds** | **Risk of MHP 4- to 12-year-olds** |
|---|---|---|---|---|---|
| | OR (95% CI) for N=1,397 | OR (95% CI) for N=1,397 | OR (95% CI) for N=1,397 | OR (95%CI) for N=896 | OR (95%CI) for N=896 |
| Model 1 | Two-way interaction parameter estimates (intervention condition in 2021) | | | | |
| | 1.23 (0.66, 2.26) | **0.61 (0.37, 0.99)** | 1.55 (0.56, 4.34) | 1.18 (0.71, 1.97) | 1.95 (0.72, 5.33) |
| Model 2 | Three-way interaction parameter estimates (difference in inequalities for the intervention condition in 2021) | | | | |
| | 0.59 (0.16, 2.09) | 0.96 (0.34, 2.68) | 0.82 (0.10, 6.57) | 0.41 (0.14 , 1.16) | 0.95 (0.11, 8.05) |

MHP=mental health problems. An odds ratio <1.00 indicates a favourable change in the outcome. **Bold** indicates statistical significance p<0.05. Model 1 is adjusted for age (continuous), gender (ref=boy) and parental education (ref=high), and includes a two-way interaction of time of measurement*condition.
Model 2 is adjusted for age (continuous) gender (ref=boy) and parental education (ref=high) and includes two-way interactions of time of measurement*condition time of measurement*parental education condition*parental education and a three-way interaction of time of measurement*condition*parental education.

Table 3 shows the main results. There is an intervention effect of the Promising Neighbourhoods program on outdoor-play. No other intervention effects on the outcomes were found (Model 1). There were no significant different intervention effects for children with a lower or higher SES on the outcomes.

Supplemental table 2 shows the exploratory analyses. No significant intervention effects were found for subscales or items of the SDQ. There were also no significant different intervention effects for children with a lower versus a higher SES.

The complete-case analyses were similar to the main analyses except that for informal parenting support a significant different intervention effect was found for children with a lower or higher SES (Supplemental table 3). As sensitivity analysis we repeated the analyses with the originally included control neighbourhood that started with common programming during this study instead of the alternative control neighbourhood that was chosen later on (Supplemental table 4). These analyses were similar to the main analyses.

## DISCUSSION

We examined the effectiveness of the Promising Neighbourhoods program in 0- to-12-year-olds on different outcomes. We found a positive intervention effect on outdoor-play. We found no other significant intervention effects and no differential effects for children with a lower or higher SES on the outcomes

We found a positive intervention effect on the outcome outdoor-play. Merzel and D'Afflitti conducted a review on community programs and found that, in general, programs employing community networks have a limited impact on population health.(14) The authors reported that the modest impact is a result of multiple factor such as methodological limitations and a limited scope and intensity.(14) To illustrate, a modest impact has also been found in a study evaluating the impact of the New Deal for Communities Program (NDC) in England.(38) The NDC was an urban regeneration program employing collaborative community engagement in 39 areas on different topics such as crime, housing and health which was compared to control areas with similar deprivation. Despite this, collaborative community-based programs such as Better Start Bradford are seen as promising for reducing inequalities in child health.(13)

There are multiple explanations for finding an intervention effect on only one outcome (outdoor-play) of the Promising Neighbourhoods program in 0- to12-year-olds.(14) First, a possible explanation for finding a positive intervention effect on outdoor-play only could be the implementation of interventions in control neighbourhoods. This is one of the reasons proposed by Merzel and D'Afflititi. (14)Additionally, gathered process indicators show that 24.0% of children/parents from intervention neighbourhoods and 25.9% in control neighbourhoods participated in interventions in the past year at follow-up. These percentages did not differ significantly. We are unaware if interventions implemented in control neighbourhoods fell under care-as-usual or if additional interventions were implemented.

Another explanation might be that the Promising Neighbourhoods program needs to be implemented for a longer period of time before more intervention effects can be expected. Our follow-up measurement took place two years after the start of the program aligned with the planning of the Promising Neighbourhoods program. An additional follow-up measurement after a longer follow-up period is warranted to give insights in possible intervention effects after a prolonged implementation period. In another community-based program called "Arnhemse Broek, Healthy and Well" which was implemented in 2004 in neighbourhoods in a Dutch city (Arnhem) a follow-up period of two year also seemed to short.(39) This community-based program that targeted adults

followed a similar approach; locally active professionals of varying organizations (e.g. police or youth work) formulated an action plan which included priorities, activities and actions for themes such as parenting problems and social safety. In their effect evaluation after two years, some positive effects were found but more negative effects were reported.(39) Unfortunately, the NDC program was implemented for ten years and not many effective results were reported.(38)

Another explanation might be that some of the chosen interventions were not the most effective interventions to achieve favourable changes on the priorities chosen. If so, this could have impacted the effectiveness of the Promising Neighbourhoods program. In the Promising Neighbourhoods program the priorities were chosen after the baseline measurement took place and not beforehand. The baseline survey measured health indicators that were deemed relevant for local health and youth policies. However, some priorities that were chosen in the intervention neighbourhoods were not measured with the survey.

Finally, it could be that the Promising Neighbourhoods program was not delivered as intended beforehand.(40, 41) A thorough process evaluation, taking into account the logic model that was set up for this evaluation, will shed more light on the implementation and increase our understanding of barriers and facilitators for the implementation of community-based programs.(42, 43)

## Methodological considerations

During the implementation of the Promising Neighbourhoods program in 2019 COVID-19 became a global pandemic. Due to the COVID-19 pandemic, interventions were cancelled, postponed or continued as online intervention. We examined this impact with an additional question in our follow-up survey. Of all parents, 37.5% responded that there were less interventions/activities in their neighbourhood due to COVID-19. There was no significant difference between intervention and control neighbourhoods. COVID-19 could have influenced the outcome measures in both intervention and control neighbourhoods but it may be possible that the effects turned out differently in intervention and control neighbourhoods. We compared the baseline and follow-up measurement in the whole sample and found that in general outcomes were similar in 2018 and 2021 (Supplemental table 1).Only the percentages of parents with informal parenting support was significantly higher at follow-up in 2021 compared to the baseline measurement in 2018. Moreover, our results regarding the effectiveness of the Promising Neighbourhoods program may not be generalizable to a situation without COVID-19.

Our study has several strengths. For the current analysis we not only studied the effect of the Promising Neighbourhoods program in intervention neighbourhoods compared to control neighbourhoods but also whether differences between children with a lower and a higher SES reduced as a consequence of the program. We used a difference-in-difference approach, which is a suitable technique to study effects of such community-based programs. Risk of MHP was measured using the SDQ, which is a validated questionnaire.(34-36) We conducted several additional analyses that are similar to our main findings.

Several limitations of our study need to be taken into consideration when interpreting the findings. First, contamination between the intervention and control neighbourhoods could have occurred. For example, when parents and their children moved from an intervention to a control neighbourhood or vice versa. Children and/or parents from control neighbourhoods could also attend schools in the intervention neighbourhoods and benefit from implemented interventions. This could have influenced the findings of our evaluation. We unfortunately do not have data to check whether this could have been the case. Second, it could be that there were interventions implemented in the control neighbourhoods. This could lead to null findings but is inherent to the design of a collaborative community-based program in the real world. For example, community stakeholders in one control neighbourhood started themselves with common programming. We have performed the analyses also using this control neighbourhood. However, the results were similar. Third, we used parental education as an indicator of SES in our analyses. Other indicators of SES might have yielded different results. Fourth, the sample size for 4-to 12-year-olds at follow-up was somewhat lower than needed to detect small effect sizes. Finally, this study took place in neighbourhoods of a large Dutch city. Findings may not be generalizable to other settings such as neighbourhoods in smaller cities, rural areas or other countries.

## Future research

For the evaluation of Promising Neighbourhoods and comparable programs more follow up measurements or a longer follow-up period is warranted as intervention effects might need a longer implementation period. The effectiveness in older youth still needs to be evaluated.

Several key actions for successful health promotion programs have been reported by Jackson *et al.,*.(10) Collaborative community-based programs like Promising Neighbourhoods include many of these key actions in their design. Perhaps, these key-actions currently were not or not yet adequately incorporated or not sufficiently addressed in the Promising Neighbourhoods program for the program to be effective. Key actions

such as intersectoral collaboration and interorganizational partnerships or community participation might just need more time to establish and become effective. It is also possible that there are other key actions needed for effective collaborative community-based programs that have not yet been identified in the study by Jackson *et al.,.(10)* Future research to community-based programs is warranted to provide these necessary insights.

Further, by additionally studying the implementation process of such programs from other perspectives such as interviews with policymakers or content analyses of policy documents will provide more insights in underlying mechanisms.

## Conclusion

The findings of this study indicate a positive intervention effect for one of the outcomes in 0- to 12-year-olds. Further mixed-methods evaluation research and using longer follow-up periods are needed to examine the value of these type of programs. Further development of Promising Neighbourhoods seems warranted.

## SUPPLEMENTAL MATERIAL

**Table S1.** Missing values for all variables used for the analyses in 2018 and 2021.

| Variables | Sample in 2018 | Missing values 2018 | Sample in 2021 | Missing values 2021 |
|---|---|---|---|---|
| **Sociodemographic variables** | | | | |
| Age | 6.0 (3.0-8.8) | 0 | 5.0 (2.0-9.0) | 1 |
| *0- to 4-year-olds* | 342 (34.8%) | | 144 (34.9%) | |
| *4- to 12-year-olds* | 642 (65.2%) | | 268 (64.9%) | |
| Gender | | 0 | | 1 |
| *Boy* | 492 50.0%) | | 197 (47.7%) | |
| *Girl* | 492 (50.0%) | | 215 (52.1%) | |
| **Socioeconomic status indicator** | | | | |
| Parental education | | 36 | | 7 |
| *High* | 504 (51.2%) | | 238 (57.6%) | |
| *Low* | 444 (45.1%) | | 168 (40.7%) | |
| **Outcomes in 0-to 12-year-olds** | | | | |
| Informal parenting support[a] | | 7 | | 2 |
| *Yes* | 578 (58.7%) | | 289 (70.0%) | |
| *No* | 399 (40.5%) | | 122 (29.5%) | |
| Outdoor-play | | 66 | | 30 |
| *Yes* | 518 (52.6%) | | 152 (36.8%) | |
| *No* | 400 (40.7%) | | 231 (55.9%) | |
| General health | | 5 | | 0 |
| *Good* | 898 (91.3%) | | 390 (94.4%) | |
| *Not good* | 81 (8.2%) | | 23 (5.6%) | |
| **Outcomes in 4- to 12-year-olds** | | | | |
| Sport club membership | | 0 | | 0 |
| *Yes* | 354 (56.1%) | | 145 (54.7%) | |
| *No* | 277 (43.9%) | | 120 (45.3%) | |
| Risk of MHP | | 2 | | 0 |
| *No* | 559 (88.9%) | | 237 (89.4%) | |
| *Yes* | 70 (11.1%) | | 28 (10.6%) | |

MHP=mental health problems. Outcome measures 0-12- year olds sample size in 2018 N=984 sample size in 2021 N=413. Outcome measures 4-12-year olds sample size in 2018 N=631 and sample size in 2021 N=265. Percentages are column percentages.

**Table S2.** Exploratory analyses using difference-in-difference regression analyses.

| | Emotional problems 4- to 12-year-olds | Anxiety 4- to 12-year-olds | Conduct problems 4- to 12-year-olds | Bullying 4- to 12-year-olds | Tantrums 4- to 12-year-olds | Stealing 4- to 12-year-olds | Being bullied 4- to 12-year-olds |
|---|---|---|---|---|---|---|---|
| | OR (95%CI) N=896 | | | | | | |
| Model 1 | Two-way interaction parameter estimates (intervention condition in 2021) | | | | | | |
| | 2.07 (0.70, 6.08) | 0.95 (0.48, 1.89) | 0.99 (0.47, 2.05) | 0.73 (0.26, 2.01) | 1.45 (0.78, 2.70) | 0.91 (0.39, 2.13) | 1..28 (0.60, 2.75) |
| Model 2 | Three-way interaction parameter estimates (difference in health inequalities for the intervention condition in 2021) | | | | | | |
| | 1.29 (0.14, 11.71) | 1.47 (0.36, 5.96) | 0.94 (0.08, 11.32) | 0.58 (0.07, 4.83) | 0.92 (0.26, 3.31) | 2.41 (0.39, 14.74) | 0.34 (0.07, 1.61) |

An odds ratio <1.00 indicates a favourable change in the outcome. **Bold** indicates statistical significance p <0.05. Model 1 is adjusted for age (continuous), gender (ref=boy) and parental education (ref=high), and includes a two-way interaction of time of measurement*condition.
Model 2 is adjusted for age (continuous) gender (ref=boy) and parental education (ref=high) and includes two-way interactions of time of measurement*condition time of measurement*parental education condition*parental education and a three-way interaction of time of measurement*condition*parental education.

**Table S3.** Difference-in-Difference regression analyses in the complete-case dataset.

| | Informal parenting support 0-to 12-year-olds | Outdoor-play 0- to 12-year-olds | General health 0- to 12-year-olds | Sport club membership 4- to 12-year-olds | Risk of MHP 4- to 12-year-olds |
|---|---|---|---|---|---|
| | OR (95% CI) for N=1,378 | OR (95% CI) for N=1,397 | OR (95% CI) for N=1,378 | OR (95%CI) for N=896 | OR (95%CI) for N=833 |
| Model 1 | Two-way interaction parameter estimates (intervention condition in 2021) | | | | |
| | 1.11 (0.65, 1.88) | **0.58 (0.35, 0.97)** | 1.55 (0.52, 4.59) | 1.26 (0.67, 2.37) | 2.20 (0.77, 6.32) |
| Model 2 | Three-way interaction parameter estimates (difference in inequalities for the intervention condition in 2021) | | | | |
| | **0.31 (0.11, 0.92)** | 0.93 (0.33, 2.64) | 1.04 (0.11, 9.90) | 0.59 (0.16, 2.15) | 0.99 (0.12, 8.40) |

An odds ratio <1.00 indicates a favourable change in the outcome. **Bold** indicates statistical significance p <0.05. Model 1 is adjusted for age (continuous), gender (ref=boy) and parental education (ref=high), and includes a two-way interaction of time of measurement*condition.
Model 2 is adjusted for age (continuous) gender (ref=boy) and parental education (ref=high) and includes two-way interactions of time of measurement*condition time of measurement*parental education condition*parental education and a three-way interaction of time of measurement*condition*parental education.

**Table S4.** Difference-in-Difference regression analyses on with another control neighbourhood.

| | **Informal parenting support 0- to 12-year-olds** | **Outdoor-play 0- to 12-year-olds** | **General health 0- to 12-year-olds** | **Sport club membership 4-to 12-year-olds** | **Risk of MHP 4- to 12-year-olds** |
|---|---|---|---|---|---|
| | OR (95% CI) for N=1,397 | OR (95% CI) for N=1,397 | OR (95% CI) for N=1,397 | OR (95%CI) for N=896 | OR (95%CI) for N=896 |
| Model 1 | Two-way interaction parameter estimates (intervention condition in 2021) | | | | |
| | 1.14 (0.68, 1.91) | **0.56 (0.34, 0.93)** | 1.58 (0.57, 4.38) | 1.53 (0.81, 2.86) | 2.40 (0.82, 7.03) |
| Model 2 | Three-way interaction parameter estimates (difference inequalities for the intervention condition in 2021) | | | | |
| | 0.63 (0.22, 1.79) | 0.85 (0.30, 2.44) | 0.49 (0.06, 3.86) | 1.06 (0.29, 3.87) | 0.54 (0.06, 4.87) |

MHP=mental health problems. An odds ratio <1.00 indicates a favourable change in the outcome. **Bold** indicates statistical significance p <0.05. Model 1 is adjusted for age (continuous), gender (ref=boy) and parental education (ref=high), and includes a two-way interaction of time of measurement*condition.
Model 2 is adjusted for age (continuous) gender (ref=boy) and parental education (ref=high) and includes two-way interactions of time of measurement*condition time of measurement*parental education condition*parental education and a three-way interaction of time of measurement*condition*parental education.

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# 10

# General discussion

The aim of this thesis was twofold. First, to contribute to the knowledge of health and well-being of children and adolescents by studying health outcomes and their risk and protective factors. The second aim was to contribute to the knowledge base of evidence-based interventions, policies and policy programs by evaluating local interventions and programs aimed to promote a healthy lifestyle, health and well-being in children and adolescents. The research questions addressed in this thesis are:

*Part 1: Analysis of health, well-being, protective and risk factors*

- What are the associations of multiple socioeconomic status indicators and migrant status with risk of a low vegetable and a low fruit consumption in 4- to 12-year old children?
- What are the associations of multiple socioeconomic status indicators and migrant status with risk of mental health problems in 4- to 12-year old children?
- What are the associations of organized sport activities and organized non-sport activities with mental health outcomes in children and adolescents based on published systematic reviews?
- What are the associations of participating in organized sport activities, organized non-sport activities and number of categories of organized activities with risk of mental health problems in a population-based sample of 4- to 12-year olds?
- What are the associations of factors on the parental, child and socio-contextual level and general parenting self-efficacy among parents with children aged 0- to 18 years?

*Part 2: Interventions and policy programs to promote healthy lifestyles, health and well-being*

- What is the effectiveness of interventions to increase the consumption of water among children aged 2- to 12-years?
- What is the effectiveness of the Promising Neighbourhoods collaborative community-based program on intermediate and ultimate outcomes and on reducing socioeconomic inequalities in intermediate and ultimate outcomes?

This final chapter discusses the main findings of the studies included in this thesis. Further, this chapter includes a discussion of the methodological issues, recommendations for future research and for public health and local policies.

## MAIN FINDINGS AND INTERPRETATION

*Part 1: Analysis of health, well-being, protective and risk factors*

### Socioeconomic inequalities in vegetable and fruit consumption and in mental health

Previous research often focused on the association of one indicator of socioeconomic status or migrant status with risk of a low vegetable or fruit consumption or with risk of mental health problems.(1-5) However, different indicators of socioeconomic status on the individual, family or neighbourhood level measure different aspects of socioeconomic status.(6, 7) Migrant status is closely related to socioeconomic status.(6, 7)

In **chapter 2** associations with risk of a low vegetable and risk of a low fruit consumption in primary school-aged children living in Rotterdam (the Netherlands) were examined for lower/intermediate versus higher parental education, perceived financial difficulties versus no perceived financial difficulties, material deprivation versus no material deprivation, lower versus higher neighbourhood socioeconomic status and a non-Western versus a Western and Dutch migrant status.

This corresponds with the first research question. In our sample of primary school-aged children, 22.1% had a low vegetable consumption (≤4 days a week) and 11.9% had a low fruit consumption (≤4 days a week). Findings of our multilevel multivariable logistic regression models indicated that having lower/intermediate educated parents, parents who experience material deprivation, being from a neighbourhood with a lower socioeconomic status and having a non-Western migrant status is associated with a relatively higher risk of a low vegetable consumption compared to having higher educated parents, parents who do not experience material deprivation, being from a neighbourhood with a higher socioeconomic status and compared to a Western or Dutch migrant status. Perceived financial difficulties were not associated with a relatively higher risk of a low vegetable consumption. Further, findings indicated that having lower/intermediate educated parents or having parents who experience material deprivation is associated with a relatively higher risk of a low fruit consumption compared to having higher educated parents or having parents who do not experience material deprivation. Financial difficulties, a non-Western migrant status or a lower socioeconomic status of the neighbourhood were not associated with a relatively higher risk of a low fruit consumption.

Likewise, in **chapter 3** associations with risk of mental health problems in primary school-aged children living in Rotterdam (the Netherlands) were examined for lower/intermediate versus higher parental education, material deprivation versus no material

deprivation, perceived financial difficulties versus no perceived financial difficulties, a lower/intermediate versus higher neighbourhood socioeconomic status and a non-Western versus a Western and Dutch migrant status. This corresponds with the second research question. In total, 9.5% (473) of all children in our sample were at risk of mental health problems, which is in line with the prevalence in primary school-aged children worldwide.(8) Findings from our multilevel multivariable logistic and linear regression models indicated that having lower/intermediate educated parents or having parents who experience material deprivation or parents who perceive financial difficulties is associated with a relatively higher risk of mental health problems in primary-school aged children compared to having higher educated parents, having parents who do not experience material deprivation or parents who do not perceive financial difficulties. The socioeconomic status of the neighbourhood or migrant status of the child were not associated with a relatively higher risk of mental health problems.

Lower/intermediate parental education and material deprivation were both associated with all three outcomes (i.e. a relatively higher risk of a low vegetable consumption, a relatively higher risk of a low fruit consumption and a relatively higher risk of mental health problems). A Non-Western migrant status and a lower socioeconomic status of the neighbourhood were only associated with a relatively higher risk of a low vegetable consumption. Perceived financial difficulties was only associated with a relatively higher risk of mental health problems. These findings indicate that there might be different pathways for the influence of socioeconomic status on health outcomes and that some pathways might be less or more relevant for specific health outcomes.

## Organized activities and mental health outcomes

Organized activities are activities that are structured, supervised by adults, emphasize skill building, are generally voluntary, have regular scheduled meetings and are not part of the school curriculum.(9-11) Examples of organized activities include but are not limited to sport, arts, scouting, music, theatre, dance and community programs.(9-11) Organized activities may help to promote mental well-being among children and adolescents.(11-13) The positive youth development theory is grounded in the socio-ecological systems theory and postulates that organized activities may offer opportunities for children and adolescents to develop relationships, engage in physical activities that increase their confidence (i.e. internal sense of positive self-worth and self-efficacy), competence (i.e. positive view of ones actions in domain specific areas including social, academic, cognitive and vocational), character (i.e. sense of morality, integrity, adherence to societal and cultural norms), caring (i.e. sense of sympathy and empathy towards others) and connectedness (i.e. positive and reciprocal relationships with others).(14-16) Consequently, it is hypothesized that children and adolescents that participate

in organized activities are at a relatively lower risk for academic, psychological, social and behavioural, problems compared to children that do not participate in organized activities.(9, 17) Features of organized activities that have been found to improve mental health are: safe and appropriate peer interactions, structure and adults supervision, forming of supporting relationships with peers and adults, emphasis on inclusion and a sense of belonging, emphasis on positive social norms, support of efficacy and sense off mattering and skills building.(10) Further, physical activity is an additional feature that may improve child and adolescent mental health.(18) This is present in organized sport activities and can also be present in organized non-sport activities.(18) Previous literature has reported an association between participation in organized activities and improved mental health.(19-23) Most studies were performed in adolescents.(19, 21, 22) Some studies also reported harmful consequences of participation in organized activities such as relatively more risk behaviour or bullying.(19, 20, 24-26)

In **chapter 4** evidence from systematic reviews about the associations of organized sport and non-sport activities on mental health problems and well-being in children and adolescents was synthesized. This corresponds with the third research question. Six systematic reviews were included in an umbrella review. The most studied outcomes were depressive symptoms and anxiety symptoms. Aspects of mental well-being were relatively less studied compared to aspects of mental health problems. Six systematic reviews examined the association of organized sport, including team-based and individual sport, level of sport involvement and resistance training. A small positive association of organized sport activities on child and adolescent mental health was observed after synthesizing findings from the systematic reviews. This was not dependent on the type of organized sport activities. A previous umbrella review found a small positive association of physical activity on child and adolescent mental health.(18) We cannot disentangle the association of organized activities on child and adolescent mental health from physical activity. None of the systematic reviews has reported this and most primary studies that were included did not adjust for physical activity. No conclusion about the association of organized non-sport activities on child and adolescent mental health could be drawn because of the few primary studies about organized non-sport activities in the systematic reviews that could be included in our synthesis. These findings indicate that organized sport activities can contribute to mental health in children and adolescents.

In **chapter 5** associations with risk of mental health problems in primary school-aged children living in Rotterdam (the Netherlands) were examined for participating in organized sport activities versus not participating in organized sport activities and participating in organized non-sport activities (singing/music/theatre, scouting, crafts

or other) versus not participating in organized non-sport activities. Associations with risk of mental health problems in primary school-aged children living in Rotterdam (the Netherlands) were also examined for participating in 2-5 categories of organized activities (sport, singing/music/theater, scouting, crafts, other) versus participating in 1 category of organized activities or not participating in any organized activities. This corresponds with the fourth research question. In this study we adjusted for physical activity. In our sample, 32.2% did not participate in any organized activity. Of all the children, 57.7% participated in an organized sport activity and 21.9% participated in an organized non-sport activity. This is in line with previous research in primary- and secondary school-aged children in Europe, Canada and Australia.(26-28)

Our findings from multivariable logistic regression models indicated that children who participated in organized sport activities and children who participated in organized non-sport activities had a relatively lower risk of mental health problems compared to children who were not involved in organized sport activities or organized non-sport activities. Children who participated in two or more categories of organized activities relatively had the lowest risk of mental health problems compared to children that participated in one category of organized activities or in none. These findings are in line with earlier research, which was mainly performed in adolescents, that has found associations of participating in organized activities and participating in a higher number of categories organized activities with a relatively lower risk of mental health problems. (27, 29, 30)

## Factors associated with parenting self-efficacy

Previous research showed that high parenting self-efficacy is associated with relatively less mental health problems and a better development in children.(31-33) A range of factors has been found to be associated with parenting self-efficacy but was mainly studied among mothers.(34-37) Previous systematic reviews that examined parenting self-efficacy have only been performed among specific populations such as parents of infants and toddlers.(38, 39)

In **chapter 6** evidence of associations of parental, child and socio-contextual factors with parenting self-efficacy in parents of children and adolescents was synthesized in a systematic review. This corresponds with the fifth research question. In total, 30 studies were included in the systematic review. Half of all studies were performed in a sample of only mothers. Across these studies, 89 potential factors were studied. Of these factors, 66 were reported by one or two studies, 5 were reported by three studies and 18 by four or more studies. The most frequently studied factors were parental factors. Findings from this systematic review indicated that there is some evidence for a positive associa-

tion of maternal parenting satisfaction, perceived social support and household income with parenting self-efficacy. Findings also indicated a negative association of parenting stress, maternal depression and child temperament with parenting self-efficacy. No associations or inconsistent findings were found for the other included factors. The factors on the parent, child and socio-contextual level that have been identified to be associated with parenting self-efficacy could be important for developing and tailoring effective parenting support interventions.

*Part 2: Interventions and policy programs to promote healthy lifestyles, health and well-being*

## Interventions to increase water consumption

Water is a healthy alternative to sugar sweetened beverages as the consumption of sugar sweetened beverages may be associated with weight gain.(40) Reducing the consumption of sugar sweetened beverages is recommended by the World Health Organization.(41) Choosing to drink water instead of sugar sweetened beverages is a dietary habit that is probably formed in childhood.(42, 43) Therefore, promoting to choose water instead of sugar sweetened beverages in childhood is important. Dietary habits are formed in the environments in which children grow up including the home, community, child day-care, pre-school and school environment. In a previous systematic review it has been found that the child's self-efficacy, parental self-efficacy and parental restrictive and encouraging feeding practices were potentially modifiable factors associated with water consumption.(44) By targeting these factors interventions may be able to promote the water consumption of children.

In **chapter 7** evidence about the effectiveness of interventions to increase the consumption of water in 2- to 12-year-olds is synthesized. This corresponds with the sixth research question. In total, 47 studies were included in the systematic review. Of these 47 studies, 24 could be included in a meta-analysis. Findings indicated that interventions could lead to a small improvement in water consumption in children. Interventions that focused on diet or beverage consumption alone had greater effects than interventions that also included other lifestyle factors. Earlier research found that combined interventions focusing on modifying a wide range of lifestyle behaviours were particularly effective in reducing weight in children.(45, 46) A possible reason for our contrasting finding is that the message of drinking water receives relatively less attention because of other lifestyle behaviours in such combined interventions. Interventions that were performed in non-school settings were more effective than interventions performed in school-settings or in combined school and non-school settings. It might be that in the non-school setting there is more room for improvement. Previous studies found

that children are more likely to consume sugar sweetened beverages in non-school settings such as home, recreation venues and on weekends.(47-50) Also it was found that lifestyle interventions in home settings achieved greater reductions in children's sugar sweetened beverage consumption compared to interventions in school-settings.(51) The findings of this systematic review confirm findings from two earlier reviews aimed at children aged 3 years and older and at children aged 0-5-year old and provides additional evidence that interventions to increase the water consumption in children have small but positive effects.(51, 52)

## Promising Neighbourhoods: A Local collaborative community-based program

Key actions that were found to be central to the effectiveness of health promotion programs are intersectoral collaboration and interorganizational partnerships (e.g. governmental organizations, non-governmental organizations and stakeholders), community participation and engagement in planning and decision-making (e.g. stakeholders), creating healthy settings, political commitment, funding and infrastructure for social policies, employing multiple strategies and actions at multiple levels and sectors and awareness of the socio-environmental context.(53, 54) To promote health at the local level and to reduce inequalities in child health local collaborative community programs are seen as promising because they include many of these key actions.(55-57) Local collaborative community programs generally employ multiple interventions, involve key-leaders and networks, and aim to strengthen the community.(18) **Chapter 8** and **chapter 9** concern a local collaborative community-based program that was implemented in Rotterdam. This corresponds with the seventh research question. This program called *"Promising Neighbourhoods"* aims to increase the health, safety and talent development of youth, and aims to contribute to the reduction of socioeconomic inequalities.This program is continuously further developed and adjusted. Also during this study the program was further developed. The program is seen as a learning process.

In **chapter 8** the design and methodology of a mixed methods evaluation study of this local collaborative community-based program was described.

**Chapter 9** includes the effect evaluation of this collaborative community-based program in a sample of 0- to 12-year-olds after two years. For the effect evaluation a quasi-experimental design with difference-in-difference regression analysis was used. The effectiveness of the collaborative community-based program was examined on informal parenting support, outdoor-play, sport club membership, general health and risk of mental health problems. A positive intervention effect was found for outdoor-play. No significant intervention effect was found for other outcomes. No differential

intervention effect for children with a lower or higher socioeconomic status was found. Also Merzel and D'Affliti found modest intervention effects in their review on community programs.(58) Similarly, other evaluation studies on comparable approaches to the Promising Neighbourhoods program reported no or modest effects.(59, 60) Merzel and D'Affliti proposed several possible explanations for finding modest effects from community programs.(58) First, collaborative community-based programs may need to be implemented for a longer time period before intervention effects can be expected. Our follow-up measurement took place two years after the start of the program in accordance with the planning for this municipal program. It could be that the program was found to be more effective if we used a wider set of outcome variables. It could also be that the dose received was too low or that children that were exposed to the interventions differed from children that needed the interventions. The interventions are chosen by the municipal district advisor together with community stakeholders from the neighbourhood. Evidence-based interventions may not always be available or other interventions might have been preferred. Finally, it could be that the program was not delivered as intended beforehand.(61, 62) Possibly the program is more effective after a longer period or in older youth.

## METHODOLOGICAL CONSIDERATIONS

### Study design and population

**Chapter 2**, **3**, and **5** in this thesis include studies that were conducted with data of 4- to 12-year-olds from the Rotterdam children's Public Health survey 2018. This survey has a cross-sectional design. No causation can be established in cross-sectional data. Because the measurement of the exposure and outcome are performed at the same time establishing a temporal order may also not be possible. Therefore, we have to be careful when interpreting data from the cross-sectional studies in this thesis.

**Chapter 8** and **chapter 9** concern the design, methodology and effect evaluation of a mixed-methods study on a collaborative community-based program. A mixed-methods study consists of qualitative and quantitative methods. For the effect evaluation part of the mixed methods study a quasi-experimental design with a difference-in-difference analysis was used. This program was implemented in three intervention neighbourhoods and compared to three control neighbourhoods in Rotterdam.

Ideally, randomized controlled trials are used to avoid confounding and to examine causal evidence about the effectiveness of interventions and programs. A confounder is a factor that is usually associated with both the intervention and the outcome but does

not lie on the causal pathway. The intervention is assigned at random in randomized controlled trials. Therefore, the intervention and outcomes are independent. Randomization helps to ensure that intervention and control groups start out equally and thus changes in the intervention group can be more easily attributed to the intervention. In real-word settings using randomized controlled trials is often not possible due to practical or ethical reasons. For example because the intervention (e.g. program or policy) is irreversible, applies to the whole population or because implementation has already started.(63) To evaluate the effect of the Promising Neighbourhoods collaborative community-based program a randomized controlled trial was indeed not possible due to logistic reasons.(64) The Promising Neighbourhoods program was already implemented in some neighbourhoods before the study started. Implementation order was dependent on the case load for municipal district advisors. Each municipal district advisor is appointed to specific neighbourhoods. Randomization within the limited number of available neighbourhoods of a district advisor was not possible or likely to result in different baseline measures. Therefore, a matching strategy was chosen stratified for degree of experienced problems (low, middle or high) which is based on the percentage of children aged 4- to 12-year olds with a high score on the Strengths and Difficulties Questionnaire score in the neighbourhoods, the percentage of overweight children in grade two of primary school in the neighbourhoods and on average socioeconomic status of neighbourhoods.

Quasi-experimental designs have a lower internal validity as randomization is not possible. However, the external validity may be higher when the program is implemented in the real-world setting.

Contamination between the intervention and the control neighbourhoods could have occurred. For example, children and their parents could have moved from intervention to control neighbourhoods or vice versa. Further children could attend schools or interventions in another neighbourhood than the neighbourhood they reside in. Also, implementation of interventions in control neighbourhoods can occur. This could lead to null findings and is one of the challenges of evaluation research in real-world settings.



## Setting

The studies included in **chapter 2,3, 5, 8** and **9** are all performed in children living in Rotterdam. Rotterdam is the second largest city in the Netherlands.(65) Rotterdam is a culturally diverse city including 52.9% of its inhabitants with a non-Dutch background.(66) Results of these studies may not be generalizable to children living in less urbanized and culturally diverse areas, cities or to children in other countries.

During the implementation of the Promising Neighbourhoods collaborative community-based program in 2019 COVID-19 became a global pandemic. This may affect the internal and external validity of the results included in **chapter 9**. Our results regarding the effectiveness of the community program may not be generalizable to a situation without COVID-19. Because of the COVID-19 pandemic, the Netherlands went into several lockdowns. Due to these lockdowns, at certain moments, children could not attend school or child care facilities. Interventions were cancelled, postponed or continued as online intervention because of COVID-19 restrictions. COVID-19 could have impacted the reach, dose and adoption of the collaborative community-based program. To examine this we added additional questions to the follow-up survey that we administered in 2021. Of all parents 37.5% responded that there were less interventions or activities in their neighbourhood due to COVID-19. This was similar across intervention and control neighbourhoods.

## Population

The response-rate can be an important indicator introducing possible selection bias (i.e. non-response bias) in cross-sectional surveys. **Chapter 2,3**, **5, 8** and **9** include studies in which the participation rate for the conducted surveys varied between 31.8-38.0%. Selection bias occurs when associations of the exposure with the outcome are different for the population that participated in the study and for the population that did not participate in the study but that was eligible for inclusion. Unfortunately in our analyses we could not examine whether characteristics of responders differed from characteristics of non-responders as no data about characteristics of those not participating was available.(67) Previous studies found that selective non-response does not automatically lead to biased results.(68, 69)

## Measurements

Most data collected in the studies included in this thesis were derived from parent-reported data. This could lead to information bias which is a potential weakness in studies with parent or self-reported data.(70) Parents may consider some questions as sensitive topics. This could have led to social desirable responding of parents. Social desirable responding is a source of measurement error in surveys and could mask relations between variables or provides false relations between variables. Social desirable responding or social desirability bias is a type of response bias in which there is a tendency to underreport social undesirable behaviour and qualities and to over report social desirable behaviour and qualities.(71, 72) Questions about material deprivation or financial difficulties which are used in the studies included in **chapter 2** and **chapter 3** could be subject to social desirable answers. Moreover, it could be that parents gave socially desirable responses about questions examining their child's organized activities

participation, mental health, and vegetable and fruit consumption which are studied in **chapter 2, 3** and **5**. Also, in **chapter 8** and **9** analyses were based on parent-reported survey data. The survey data that were used in chapter **2, 3, 5, 8** and **9** were anonymous. It has been shown that anonymous surveys are less prone to social desirability bias but still can be subject to social desirability bias.(73)

Parents could report inaccurate answers because they cannot remember the full details. This could for example occur when parents answer questions related to physical activity or vegetable and fruit consumption. Vegetable and fruit consumption was used in the study included **chapter 2.** Physical activity is used in the study included in **chapter 5, 8** and **9.** This bias is also known as recall bias.

Parents may also not always be aware of the physical activity or vegetable and fruit consumption of their children. For example because children also spend time at day-care and at school. This could lead to an under-or overestimation of the actual amount.

## RECOMMENDATIONS FOR FUTURE PUBLIC HEALTH RESEARCH

*Part 1: Analysis of health, well-being, protective and risk factors*

The studies included in this thesis reveal that different socioeconomic status indicators are associated with risk of a low vegetable consumption, risk of a low fruit consumption and with risk of mental health problems. Further research, preferably of longitudinal nature, to replicate these findings and to further unravel possible pathways of socioeconomic health inequalities by applying mediation analyses (e.g. self-efficacy, attitudes, preferences, knowledge, intentions, availability of ready-to-eat facilities and healthy food facilities in the neighbourhood and acculturation for vegetable and fruit consumption and maternal depressive symptoms, stress, parenting skills and practices for mental health) is warranted.

The studies in this thesis indicate a possible positive contribution of participation in organized activities on mental health in children and adolescents. However, more studies, preferably longitudinal designs, are warranted to verify the findings of the cross-sectional analysis and the findings of the umbrella review included in this thesis. Particularly research on organized non-sport activities is warranted as these studies are relatively scarce. To get more insight in possible pathways future studies should focus on examining associations of the frequency, intensity, duration, setting (individual or group-based) and trajectories of participation in organized activities with mental health

in children and adolescents. Future studies should also try to disentangle the impact of participating in organized activities from mere physical activity on mental health as many included studies in the umbrella review did not adjust for physical activity in their analyses.

Most studies included in the systematic review on factors associated with parenting self-efficacy that is embedded in this thesis were of cross-sectional nature and thus more longitudinal studies are warranted to examine associations of factors with parenting self-efficacy over time. Bi-directional associations and possible mediation or moderation of factors associated with parenting self-efficacy should also be explored.(74) Most research on factors associated with parenting self-efficacy has been performed in mothers. Fathers also contribute to their children's development. Further research is needed to explore which, possibly differing, factors are associated with self-efficacy in fathers and how this contributes to the development of children.(75)

*Part 2: Interventions and policy programs to promote healthy lifestyles, health and well-being*

Interventions to increase the water consumption in children were found to be most effective if they focused on dietary behaviour or beverage consumption solely. More research is needed to understand which specific other intervention elements (e.g. socioecological level, setting) have the greatest effect on water consumption in children. Future research is also needed to determine whether interventions to increase the water consumption in children also decrease sugar-sweetened beverage consumption and improve the weight status of children.

The evaluation of the Promising Neighbourhoods collaborative community-based program after two years showed positive effect on outdoor-play in 0-to 12-year olds. For the evaluation of collaborative community-based programs like Promising Neighbourhoods further research is warranted using multiple follow-up measurements or longer follow-up periods as the intervention effects might need a longer intervention period to be effective. The effectiveness of Promising Neighbourhoods in youth aged 12 years or older has not yet been evaluated.

In previous research key actions for effective health promotion programs have been reported.(53) Key actions that have been reported are intersectoral collaboration and interorganizational partnerships, participation and engagement in planning and decision-making, healthy settings (e.g. municipalities), political commitment, funding and infrastructure for social policies, multiple strategies at multiple levels across

multiple sectors and awareness of the socio-environmental context.(53) Collaborative community-based programs like Promising neighbourhoods include many of these key actions in their design. To elucidate why programs like the Promising Neighbourhoods program only show modest effects despite including these key actions, it is warranted to study the role of these key actions. Probably key actions are not adequately incorporated or not sufficiently addressed for the programs to be effective. Some key actions such as intersectoral collaboration and interorganizational partnerships or community participation might need more time to establish and become effective. Perhaps, there are other key actions needed for effective for programs like Promising Neighbourhoods that have not yet been identified by the study by Jackson *et al.,*.(53) Therefore, by additionally studying the implementation process of such programs from other perspectives such as interviews with policymakers or content analyses of policy documents will provide more insights in underlying mechanisms.

## FUTURE DIRECTIONS FOR LOCAL PUBLIC HEALTH

*Part 1: Analysis of health, well-being, protective and risk factors*

It is important for interventions, policies and policy programs to have insight in the children and adolescents at risk. In the studies included in this thesis associations of multiple socioeconomic status indicators and migrant status with a relatively higher risk of a low vegetable consumption, a relatively higher risk of a low fruit consumption and with relatively higher risk of mental health problems were examined. Generally, the studies included in this thesis showed that interventions, policies and policy programs focusing on children with a lower socioeconomic status is warranted.

For all three outcomes (i.e. a relatively higher risk of a low vegetable consumption, a relatively higher risk of a low fruit consumption and a relatively higher risk of mental health problems), several associations of socioeconomic status indicators (parental educational level, material deprivation, perceived financial difficulties and SES of neighbourhood) and migrant status were found. Therefore, when implementing interventions, policies and policy programs at the local level which group to target or tailor to needs to be carefully considered.

The findings of the studies included in this thesis indicate that the mental health of children and adolescents could benefit from participation in different types of organized sport and possibly also organized non-sport activities. Children that participated in 2-5 categories of organized sport and non-sport activities had a relatively lower risk

of mental health problems than children that participated in 1 category of organized activities. Preventive interventions, policies and policy programs at the local level could contribute to better mental health by stimulating more children and adolescents to participate in organized sport activities and in organized non-sport activities. Further, preventive interventions, policies and policy programs at the local level could contribute to the increase of the number of categories of organized activities that children and adolescents participate in.

The findings from the systematic review on parenting self-efficacy in parents of 0- to 18-year-olds in the general population included in this thesis indicate that maternal parenting satisfaction, parenting stress, maternal depression, child temperament, household income and perceived social support were associated with parenting self-efficacy. There is some evidence that these factors are important to adress in parenting self-efficacy interventions. Professionals and policymakers should be aware of this.

*Part 2: Interventions and policy programs to promote healthy lifestyles, health and well-being*

Interventions that targeted dietary behaviour or beverage consumption solely and interventions that were implemented outside of the school setting were most effective. That interventions focused only on dietary behaviour or beverage consumption and interventions in a non-school setting (e.g. community or home) were found to be most effective needs to be taken into account by policymakers and professionals for the development and implementation of effective interventions to promote water consumption.

An effect-evaluation after two years showed a positive intervention effect of the Promising Neighbourhoods collaborative community-based-program in children aged 0- to 12 years old on one of the outcomes. Continued improvement of this type of programs and continuous monitoring will yield insights for the promotion of health and well-being in youth.





## GENERAL CONCLUSION

The aim of this thesis was twofold. The first aim was to contribute to the knowledge of health and well-being of children and adolescents by studying health outcomes and their protective and risk factors. The second aim was to contribute to the knowledge base of evidence-based interventions, policies and policy programs by evaluating local

interventions and programs aimed to promote the health and well-being in children and adolescents

We found that several socioeconomic status indicators and migrant status were associated with three health outcomes (i.e. a relatively higher risk of low vegetable consumption, a relatively higher risk of a low fruit consumption and a relatively higher risk of mental health problems) in children aged 4- to 12-years-old, but not all were relevant for each type of health outcome. As different pathways may lead to socioeconomic health inequalities it should be carefully considered to which groups tailoring and targeting of interventions, policies and policy programs is needed.

We found indications for protective and risk factors for child and adolescent mental health status and parenting self-efficacy. Participating in organized sport and non-sport activities may be a protective factor for mental health in children and adolescents. Participating in more categories of organized activities compared to participating in one category of organized activities may be even more protective. Further we found possible protective (maternal parenting satisfaction, perceived social support and household income) and risk factors (parenting stress, maternal depression, and child temperament) for parenting self-efficacy among parents of 0- to 18-year olds. These insights on protective and risk factors may be used for preventive interventions, policy programs and policies on the local level.

We contributed to the knowledge-base of evidence-based interventions, policies and policy programs that aimed to promote the health and well-being in children and adolescents. We found evidence for effective interventions to increase the water consumption in pre- and primary-school -aged children. Interventions were most effective if they focused on dietary behaviour or beverage consumption solely and if interventions were implemented in the home or community setting instead of the school-setting. After a two-year follow-up the Promising Neighbourhoods program yielded a positive intervention on effect on one of the outcomes (outdoor-play). Further improvement of the program is warranted.

Overall, insights were found on the association of different aspects of socioeconomic status with specific health outcomes, on protective and risk factors of important health outcomes as well as on evidence for the effectiveness of public health interventions. Insights from public health research can contribute to local interventions, policies and policy programs for the promotion of the health and well-being of children and adolescents.

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# Appendices

## SUMMARY

The World Health Organization Europe has set out multiple priorities for improving child and adolescent health and well-being in European countries in their report that is called: "European Child and Adolescent Health Strategy 2015-2020". Two of these priorities for public health issues will be studied in this thesis. These are mental health problems and reducing obesity and overweight by promoting healthy nutrition and physical activity. Moreover, in this report it is recognized that all children and adolescents should deserve good quality parenting, and that socioeconomic health inequalities in children and adolescents are also a public health issue. Parenting and socioeconomic health inequalities will also be studied in this thesis.

Public health and health promotion can be employed at international, national, regional and local levels. Particularly local governmental bodies such as municipalities play an increasingly important role in promoting the health and well-being and in reducing health inequalities of children and adolescents. Local governmental bodies can play an important role in reducing mental health problems, overweight/obesity and socioeconomic inequalities in health and in promoting mental health, a healthy diet and physical activity by implementing preventive policies, policy programs or interventions. How exactly local public health can promote the health and well-being of children and adolescents relies partly on the available knowledge.

Research is important for designing and implementing effective interventions, policies and policy programs at the local level. First, research to the health, and well-being and to protective and risk factors for certain health outcomes is important. Second, research evaluating the effectiveness and process of implementation, effective elements of interventions, policies and policy programs is also needed.

This thesis aimed to contribute to the knowledge of health and well-being of children and adolescents by studying potential target populations and to investigate health outcomes and their risk and protective factors. The second aim was to contribute to the knowledge base of evidence-based interventions, policies and policy programs by evaluating local interventions and programs to promote healthy lifestyles, health and well-being in children and adolescents.

The following research questions were addressed:

*Part 1: Analysis of health, well-being, protective and risk factors*

- What are the associations of multiple socioeconomic status indicators and migrant status with risk of a low vegetable and a low fruit consumption in 4- to 12-year old children?
- What are the associations of multiple socioeconomic status indicators and migrant status with risk of mental health problems in 4- to 12-year old children?
- What are the associations of organized sport activities and organized non-sport activities with mental health outcomes in children and adolescents based on published systematic reviews?
- What are the associations of participating in organized sport activities, organized non-sport activities and number of categories of organized activities with risk of mental health problems in a population-based sample of 4- to 12-year olds?
- What are the associations of factors on the parental, child and socio-contextual level with general parenting self-efficacy among parents with children aged 0- to 18 years?

*Part 2: Interventions and policy programs to promote healthy lifestyles, health and well-being*

- What is the effectiveness of interventions to increase the consumption of water among children aged 2- to 12-years?
- What is the effectiveness of the Promising Neighbourhoods collaborative community based program on intermediate and ultimate outcomes and on reducing socioeconomic inequalities in intermediate and ultimate outcomes?

For this thesis, we used data from the Rotterdam children's Public Health survey 2018, from an umbrella review, from two systematic reviews and from the Promising Neighbourhoods program.

Part 1 of this thesis focused on the health and well-being of children and adolescents by studying health outcomes and their protective and risk factors. Part 2 of this thesis focused on the evaluation of local interventions and programs aimed to promote healthy lifestyles, health and well-being in children and adolescents.



*Part 1: Analysis of health, well-being, protective and risk factors*

**Chapter 2** includes a cross-sectional study on associations of multiple socioeconomic status indicators and migrant status with risk of a low vegetable and a low fruit consumption. This study shows that multiple indicators of socioeconomic status and migrant

status are associated with relatively higher risk of a low vegetable consumption and with a relatively higher risk of a low fruit consumption in primary school-aged children. Children with low/intermediate educated parents, with parents who experience material deprivation, who are from a neighbourhood with a low socioeconomic status or children with a non-Western migrant status have a relatively higher risk of a low vegetable consumption compared to children that have higher educated parents, parents who do not experience material deprivation, being from a neighbourhood with a higher socioeconomic status and compared to a Western or Dutch migrant status. Children with low/intermediate educated parents or with parents who experience material deprivation have a relatively higher risk of a low fruit consumption compared to children that have higher educated parents or parents who do not experience material deprivation. The results of this study reveal that there are different indicators of socioeconomic status and migrant status that are associated with relatively higher risk of a low vegetable or a low fruit consumption. Further research, preferably of longitudinal nature, to replicate these findings and to further unravel the possible pathways underlying these associations by applying mediation analyses is warranted. The findings of this study could contribute to more interventions, policies or policy programs that are effective to promote vegetable or fruit consumption in primary school-aged children.

**Chapter 3** includes a cross-sectional study on associations of multiple socioeconomic status indicators and migrant status with risk of mental health problems. This study shows that multiple indicators of socioeconomic status were associated with a relatively higher risk of mental health problems in primary school-aged children. Children with low/intermediate educated parents, with parents who experience material deprivation or with parents who perceive financial difficulties have a relatively higher risk of mental health problems compared to children with higher educated parents, with parents who do not experience material deprivation or who do not perceive financial difficulties. Further research is needed to unravel the possible pathways behind these associations of socioeconomic status indicators with a relatively higher risk of mental health problems. This could be studied by applying by mediation analyses, performed in longitudinal data. The findings of this study could contribute to more interventions, policies or policy programs that are effective to reduce the risk of mental health problems in primary school-aged children.

**Chapter 4** includes the results of an umbrella review including systematic reviews with or without meta-analyses about the associations of organized sport and non-sport activities with mental health outcomes in children and adolescents. Six systematic reviews were included. The most studied outcomes were depressive symptoms and anxiety symptoms. Aspects of mental well-being were relatively less studied compared to as-

pects of mental health problems. Findings from this umbrella review indicate that there is an indication of a small positive impact on mental health outcomes in children and adolescents for participating in team sport, in (school) club sport, and in extracurricular and community sport. Limited evidence was found for organized non-sport activities as there was no systematic review included that primarily studied the impact of organized non-sport activities and only two systematic reviews included studies on organized non-sport activities. The association of organized activities on mental health outcomes in children and adolescents cannot be disentangled from the association of physical activity as most primary studies did not adjust for physical activity in their analyses and none of the included systematic reviews has reported on this possible confounding or mediation. More research to disentangle the association of participating in organized activities from mere physical activity on mental health outcomes is warranted. The findings of this study could contribute to more local interventions, policies and policy programs that may enhance participation of children and adolescents in organized sport activities.

**Chapter 5** includes a cross-sectional study in which associations of organized sport activities, organized non-sport (singing/music/theatre, scouting, crafts, or other) activities and number of categories of organized activities with risk of mental health problems in primary-school aged children was examined. Findings of this study indicate that primary school-aged children that participate in organized sport or organized non-sport activities have a relatively lower risk of mental health problems compared to children that do not participate in organized sport activities or organized non-sport activities. Children that participated in 2-5 different categories of organized activities had a relatively lower risk of mental health problems compared to children that that participated in 1 category of organized activities. In this study we adjusted for sociodemographic factors, stressful life events and physical activity. We had no data on the frequency, intensity, duration, setting or trajectories of participation. Future research, preferably of longitudinal nature, to unravel possible pathways should focus on studying the frequency, intensity, duration, setting and trajectories of participation in organized activities with mental health. The findings of this study could contribute to more preventive interventions, policies and policy programs at the local level that may enhance participation of children in organized activities.



**Chapter 6** includes a systematic review on associations of parental, child and sociocontextual factors with parenting self-efficacy. In total, 30 studies were included in this systematic review. Most included studies were cross-sectional. The most frequently studied factors were parental factors. This systematic review shows that there is evidence of associations of child temperament, maternal parenting satisfaction, parenting stress,

maternal depression, household income and perceived social support with parenting self-efficacy. There is some evidence that these factors are important. Professionals and policymakers should be aware of this. Research on self-efficacy of fathers is scarce. This information may be used to improve parenting support interventions.

*Part 2: Interventions and policy programs to promote healthy lifestyles, health and well-being*

**Chapter 7** includes a systematic review and meta-analysis on the effectiveness of interventions to increase the water consumption in 2- to 12-year old children. The systematic review included 47 studies of which 24 were included in the meta-analysis. The results indicate that interventions to increase the water consumption in children can be effective. Interventions that focused on dietary behaviour or beverage consumption solely and interventions that were implemented outside the school setting were found to be the most effective. More research is needed to understand which specific intervention elements have the greatest effect on water consumption in children. Future research is also needed to determine whether these interventions are also effective in reducing the consumption of sugar-sweetened beverages in children. Policymakers and professionals should take into account that interventions that focused on dietary behaviour or beverage consumption alone and interventions in a non-school setting were found to be the most effective.

**Chapter 8** describes the design and methodology for a mixed-methods evaluation study on the Promising Neighbourhoods collaborative community based program. The aim of the program is to increase the health, safety and talent development hereby indirectly reducing socioeconomic inequalities in youth (0- to 18-year-olds) living in Rotterdam. The program consists of collaborating with community stakeholders, data-based priority setting, knowledge-and theory-based policies, and implementation of evidence-based interventions.

**Chapter 9** includes the effect evaluation of the Promising Neighbourhoods collaborative community based program in 0- to 12-year-olds. The program was implemented in three intervention neighbourhoods that were compared to three control neighbourhoods in Rotterdam. The effect evaluation had a quasi-experimental difference-in-difference design with a baseline measurement in 2018 and a follow-up measurement in 2021. The effect evaluation was studied on informal parenting support, outdoor-play, sport club membership, general health and risk of mental health problems. There was a positive intervention effect on outdoor-play of the promising neighbourhoods collaborative community-based program two years after implementation.

Further research is warranted using multiple follow-up measurements or longer follow-up periods as the intervention effects might need a longer intervention period to be more effective. This is also recommended for other collaborative community-based programs. The effectiveness of this particular collaborative community based program in youth aged 12 years or older has not yet been evaluated. Further, by additionally studying the implementation process of such programs from other perspectives such as interviews with policymakers or content analyses of policy documents will provide more insights in underlying mechanisms. Further improvement of the program is warranted.

**Chapter 10** includes the discussion with an interpretation of the findings, methodological considerations and recommendations for future research and for local public health. The following conclusions can be drawn based upon the studies included in this thesis.

The aim of this thesis was twofold. The first aim was to contribute to the knowledge of health and well-being of children and adolescents by studying health outcomes and their protective and risk factors. The second aim was to contribute to the knowledge base of evidence-based interventions, policies and policy programs by evaluating local interventions and programs aimed to promote the health and well-being in children and adolescents.

We found that several socioeconomic status indicators and migrant status were associated with three health outcomes (i.e. a relatively higher risk of a low vegetable consumption, a relatively higher risk of a low fruit consumption and a relatively higher risk of mental health problems) in children aged 4- to 12-years-old, but not all were relevant for each type of health outcome. As different pathways may lead to socioeconomic health inequalities it should be carefully considered to which groups tailoring and targeting of interventions, policies and policy programs is needed.

We found indications for protective and risk factors for child and adolescent mental health status and parenting self-efficacy. Participating in organized sport and non-sport activities may be a protective factor for mental health in children and adolescents. Participating in more categories of organized activities compared to participating in one category of organized activities may be even more protective. Further we found possible protective (maternal parenting satisfaction, perceived social support and household income) and risk factors (parenting stress, maternal depression, and child temperament) for parenting self-efficacy among parents of 0- to 18-year-olds. These insights on protective and risk factors may be used for preventive interventions, policy programs and policies on the local level.

We contributed to the knowledge-base of evidence-based interventions, policies and policy programs that aimed to promote the health and well-being in children and adolescents. We found evidence for effective interventions to increase the water consumption in pre- and primary-school -aged children. Interventions were most effective if they focused on dietary behaviour or beverage consumption solely and if interventions were implemented in the home or community setting instead of the school-setting. After a two-year follow-up the Promising Neighbourhoods program yielded a positive intervention effect on one of the outcomes (outdoor-play). Further improvement of the program is warranted.

Overall, insights were found on the association of different aspects of socioeconomic status with specific health outcomes, on protective and risk factors for health outcomes as well as on evidence for the effectiveness of public health interventions. Insights from public health research can contribute to local interventions, policies and policy programs for the promotion of the health and well-being of children and adolescents.

## SAMENVATTING

De Wereldgezondheidsorganisatie Europa heeft meerdere prioriteiten gesteld voor het bevorderen van de gezondheid en welzijn van kinderen en adolescenten in hun rapport genaamd "European Child and Adolescent Health Strategy 2015-2020". Twee van deze prioriteiten voor problemen op het gebied van publieke gezondheid zullen worden bestudeerd in dit proefschrift. Dit zijn psychosociale problemen en het terugdringen van obesitas en overgewicht door het bevorderen van gezonde voeding en beweging. Bovendien wordt in dit rapport benoemd dat alle kinderen en adolescenten recht hebben op kwalitatief goed ouderschap en dat sociaaleconomische gezondheidsverschillen bij kinderen en adolescenten ook een publiek gezondheidsprobleem is. In dit proefschrift zullen ook ouderschap en sociaaleconomische gezondheidsverschillen worden bestudeerd.

Publieke gezondheid en gezondheidsbevordering kunnen worden ingezet op internationaal, nationaal, regionaal en lokaal niveau. Met name lokale overheidsinstanties zoals gemeenten spelen een steeds belangrijkere rol bij het bevorderen van de gezondheid en het welzijn en bij het verminderen van gezondheidsverschillen van kinderen en adolescenten. Lokale overheidsinstanties kunnen een belangrijke rol spelen bij het verminderen van psychosociale problemen, overgewicht/obesitas en sociaaleconomische gezondheidsverschillen en bij het bevorderen van de psychosociale gezondheid, gezonde voeding en lichaamsbeweging door het implementeren van preventief beleid, beleidsprogramma's en interventies. Hoe publieke gezondheid op lokaal niveau precies de gezondheid en welzijn van kinderen en adolescenten kan bevorderen is mede afhankelijk van de beschikbare kennis.

Onderzoek draagt bij aan deze kennis en is belangrijk voor het ontwerpen en implementeren van effectieve interventies, beleid, en beleidsprogramma's op lokaal niveau. Als eerste is onderzoek naar de gezondheid en het welzijn en naar beschermende en risicofactoren voor bepaalde gezondheidsuitkomsten belangrijk. Als tweede is ook onderzoek nodig dat de effectiviteit, het implementatieproces en effectieve elementen van interventies, beleid en beleidsprogramma's evalueert.

Dit proefschrift had als doel om bij te dragen aan de kennis over de gezondheid en welzijn van kinderen en adolescenten door potentiële doelgroepen te bestuderen en gezondheidsuitkomsten en hun risico- en beschermende factoren te onderzoeken. Het tweede doel was om bij te dragen aan de kennis over effectieve interventies, beleid en beleidsprogramma's ter bevordering van een gezonde leefstijl, gezondheid en welzijn van kinderen en adolescenten.

De volgende onderzoeksvragen kwamen aan bod:

*Deel 1: Analyse van gezondheid, welzijn, beschermende en risicofactoren*

- Wat zijn de associaties van meerdere sociaaleconomische statusindicatoren en migratiestatus met het risico op een lage groente- en lage fruitconsumptie bij 4- tot 12-jarige kinderen?
- Wat zijn de associaties van meerdere sociaaleconomische statusindicatoren en migratiestatus met het risico op psychosociale problemen bij 4- tot 12-jarige kinderen?
- Wat zijn de associaties van georganiseerde sportactiviteiten en georganiseerde non-sport activiteiten met psychosociale gezondheidsuitkomsten bij kinderen en adolescenten op basis van gepubliceerde systematische reviews?
- Wat zijn de associaties van deelname aan georganiseerde sportactiviteiten, georganiseerde non-sport activiteiten en het aantal categorieën van georganiseerde activiteiten met het risico op psychosociale problemen bij 4- tot 12-jarige kinderen uit een populatie-gebaseerde steekproef?
- Wat zijn de associaties van factoren op ouder-, kind- en sociaal-contextueel niveau met het algemeen vertrouwen van ouders in hun eigen opvoedcompetenties van ouders met kinderen van 0 tot 18 jaar?

*Deel 2: Interventies en beleidsprogramma's ter bevordering van een gezonde leefstijl, gezondheid en welzijn*

- Wat is de effectiviteit van interventies om de waterconsumptie van kinderen van 2 tot 12 jaar te verhogen?
- Wat is de effectiviteit van de wijkprogrammering in het Rotterdamse Kansrijk Opgroeien programma op tussentijdse en uiteindelijke uitkomsten en op het terugdringen van sociaaleconomische ongelijkheid op deze tussentijdse en uiteindelijke uitkomsten?

Voor dit proefschrift hebben we data gebruikt uit de Rotterdamse Kindermonitor 2018, van een overkoepelend systematisch literatuuronderzoek (umbrella review), uit twee systematische literatuuronderzoeken (reviews) en uit het programma Kansrijk Opgroeien.

Deel 1 van dit proefschrift was gericht op de gezondheid en het welzijn van kinderen en adolescenten door gezondheidsuitkomsten en hun beschermende en risicofactoren te bestuderen. Deel 2 van dit proefschrift was gericht op de evaluatie van lokale interventies en programma's gericht op het bevorderen van een gezonde leefstijl, gezondheid en welzijn bij kinderen en adolescenten.

*Deel 1: Analyse van gezondheid, welzijn, beschermende en risicofactoren*

**Hoofdstuk 2** bevat een dwarsdoorsnedeonderzoek naar associaties van meerdere sociaaleconomische statusindicatoren en migratiestatus met het risico op een lage groente-en fruitconsumptie. Deze studie laat zien dat meerdere indicatoren van sociaaleconomische status en migratiestatus geassocieerd zijn met een relatief hoger risico op een lage groenteconsumptie en met en relatief hoger risico op een lage fruitconsumptie bij kinderen in de basisschoolleeftijd. Kinderen met lager/middelbaar opgeleide ouders, kinderen in gezinnen met geldgebrek, kinderen die wonen in wijk met een lage sociaaleconomische status en kinderen met een niet-Westerse migratiestatus hebben een relatief hoger risico op een lage groenteconsumptie ten opzichte van kinderen met hoger opgeleide ouders, met ouders die geen geldgebrek ervaren, kinderen die wonen in een wijk met een hogere sociaaleconomische status en kinderen met een Westerse of Nederlandse migratiestatus. Kinderen met lager/middelbaar opgeleide ouders of kinderen in gezinnen met geldgebrek hebben een relatief hoger risico op een lage fruitconsumptie in vergelijking met kinderen met hoger opgeleide ouder of ouders die geen geldgebrek ervaren. De resultaten uit dit onderzoek laten zien dat verschillende sociaaleconomische statusindicatoren en migratiestatus geassocieerd zijn met een relatief hoger risico op een lage groente- of en lage fruitconsumptie. Verder onderzoek, bij voorkeur longitudinaal, om deze bevindingen te repliceren en om de mogelijke paden die ten grondslag liggen aan deze associaties verder uit te zoeken door middel van mediatieanalyse is nodig. De bevindingen van dit onderzoek kunnen bijdragen aan meer interventies, beleid of beleidsprogramma's die effectief zijn om groente-of fruitconsumptie bij kinderen in de basisschoolleeftijd te bevorderen.

**Hoofdstuk 3** bevat een dwarsdoorsnedeonderzoek naar associaties van meerdere sociaaleconomische statusindicatoren and migratiestatus met het risico op psychosociale problemen. Deze studie laat zien dat meerdere indicatoren van sociaaleconomische status geassocieerd zijn met een relatief hoger risico op psychosociale problemen bij kinderen in de basisschoolleeftijd. Kinderen met lager/middelbaar opgeleide ouders, kinderen in gezinnen met geldgebrek of ouders die moeite hebben met rondkomen hebben een relatief hoger risico op psychosociale problemen dan kinderen met hoger opgeleide ouders, kinderen in gezinnen die geen geldgebrek ervaren of ouders die geen moeite hebben met rondkomen. Verder onderzoek is nodig om de mogelijke paden achter de associaties van deze sociaaleconomische statusindicatoren met een relatief hoger risico op psychosociale problemen te ontrafelen. Dit zou kunnen worden onderzocht doormiddel van mediatieanalyses, uitgevoerd in longitudinale data. De bevindingen van dit onderzoek zouden kunnen bijdragen aan meer interventies, beleid

of beleidsprogramma's die effectief zijn om het risico op psychosociale problemen bij kinderen in de basisschoolleeftijd te verminderen.

**Hoofdstuk 4** bevat de resultaten van een overkoepelend systematisch literatuuronderzoek op basis van systematische literatuuronderzoeken met of zonder meta-analyses over de associaties van georganiseerde sport en non-sport activiteiten met psychosociale gezondheidsuitkomsten bij kinderen en adolescenten. Zes systematische literatuuronderzoeken werden geïncludeerd. De meest bestudeerde uitkomsten waren depressieve symptomen en angstsymptomen. Aspecten van psychosociaal welbevinden werden relatief minder bestudeerd in vergelijking met aspecten van psychosociale problemen. Bevindingen uit dit overkoepelende literatuuronderzoek geven aan dat er een indicatie is van een kleine positieve impact op de psychosociale gezondheidsuitkomsten bij kinderen en adolescenten voor deelname aan teamsport, in (school) clubsport, en in buitenschoolse en gemeenschapssport. Beperkt bewijs is gevonden voor georganiseerde non-sport activiteiten omdat er geen systematische review was die voornamelijk de impact van georganiseerde non-sport activiteiten bestudeerde en slechts twee systematische literatuuronderzoeken bevatten studies over georganiseerde non-sportactiviteiten. De associatie van georganiseerde activiteiten met de psychosociale gezondheidsuitkomsten bij kinderen en adolescenten kan niet worden losgekoppeld van de associatie van fysieke activiteit, aangezien de meeste primaire onderzoeken in hun analyses niet hebben gecorrigeerd voor fysieke activiteit en geen van de geïncludeerde systematische reviews heeft gerapporteerd over deze mogelijke verstorende factor of mediatie. Meer onderzoek om de associatie van deelname aan georganiseerde activiteiten te ontwarren van louter fysieke activiteit op de psychosociale gezondheidsuitkomsten is nodig. De bevindingen van dit onderzoek kunnen bijdragen aan meer lokale interventies, beleid en beleidsprogramma's die de deelname van kinderen en adolescenten aan georganiseerde sportactiviteiten kunnen vergroten.

**Hoofdstuk 5** bevat een dwarsdoorsnedeonderzoek naar associaties van georganiseerde sportactiviteiten, georganiseerde non-sport activiteiten (zang/muziek/theater, scouting, knutselen, en andere activiteiten), en aantal categorieën van georganiseerde activiteiten met risico op psychosociale problemen bij kinderen in de basisschoolleeftijd. Bevindingen uit dit onderzoek geven aan dat kinderen in de bassischoolleeftijd die deelnemen aan georganiseerde sport of georganiseerde non-sport activiteiten een relatief lager risico hebben op psychosociale problemen in vergelijking met kinderen die niet deelnemen aan georganiseerde sport of non-sport activiteiten. Kinderen die deelnamen aan 2-5 verschillende categorieën van georganiseerde activiteiten hadden een relatief lager risico op psychosociale problemen in vergelijking met kinderen die deelnamen aan 1 categorie van georganiseerde activiteiten. In dit onderzoek hebben we

gecorrigeerd voor socio-demografische factoren, ingrijpende gebeurtenissen en fysieke activiteit. We hadden geen informatie over de frequentie, intensiteit, duur, setting of trajecten van deelname. Toekomstig onderzoek, bij voorkeur longitudinaal van aard, om mogelijke paden te ontrafelen, zou zich moeten richten op het bestuderen van de frequentie, intensiteit, duur, setting en trajecten van deelname aan georganiseerde activiteiten met psychosociale gezondheid. De bevindingen van dit onderzoek kunnen bijdragen aan meer preventieve interventies, beleid, en beleidsprogramma's op lokaal niveau die de deelname van kinderen georganiseerde activiteiten kunnen vergroten.

**Hoofdstuk 6** bevat een systematisch literatuuronderzoek over associaties van ouder-, kind-, en sociaal-contextuele factoren met vertrouwen van ouders in hun eigen opvoedcompetenties. In totaal werden 30 studies in dit systematische literatuuronderzoek geïncludeerd. De meeste geïncludeerde studies waren dwarsdoorsnedeonderzoeken. De meest onderzochte factoren waren ouderfactoren. Dit systematische literatuuronderzoek laat zien dat er aanwijzingen zijn voor associaties van temperament van het kind, tevredenheid van de moeder over opvoeden, opvoedstress, depressie van de moeder, huishoudinkomen, en ervaren sociale steun met het vertrouwen van ouders in hun eigen opvoedcompetenties. Er zijn aanwijzingen dat deze factoren belangrijk zijn. Professionals en beleidsmakers dienen zich hier bewust van te zijn. Onderzoek bij vaders naar het eigen vertrouwen in de opvoedcompetenties is schaars. Deze kennis kan worden gebruikt om de opvoedondersteunende interventies te verbeteren.

*Deel 2: Interventies en beleidsprogramma's ter bevordering van een gezonde leefstijl, gezondheid en welzijn*

**Hoofdstuk 7** bevat een systematisch literatuuronderzoek en meta-analyse van de effectiviteit van interventies om de waterconsumptie van 2-12-jarige kinderen te verhogen. De systematische review bevat 47 studies, waarvan 24 geïncludeerd konden worden in de meta-analyse. De resultaten geven aan dat interventies om het watergebruik bij kinderen te verhogen effectief kunnen zijn. Interventies die uitsluitend gericht waren op voedingsgedrag of drinken en interventies die buiten de schoolomgeving waren ingevoerd bleken het meest effectief. Er is meer onderzoek nodig om te begrijpen welke specifieke interventie-elementen het grootste effect hebben op de waterconsumptie van kinderen. Toekomstig onderzoek is ook nodig om te bepalen of deze interventies ook effectief zijn in het verminderen van de consumptie van met suiker gezoete dranken bij kinderen. Beleidsmakers en professionals dienen er rekening mee te houden dat interventies die alleen gericht waren op voedingsgedrag of drinken en interventies in een omgeving anders dan de schoolomgeving het meest effectief bleken te zijn.

**Hoofdstuk 8** beschrijft het ontwerp en de methodologie voor een evaluatieonderzoek met kwalitatieve en kwantitatieve onderzoeksmethoden (mixed-methods) van de wijkprogrammering in het Rotterdamse Kansrijk Opgroeien programma. Het doel van het programma is om de gezondheid, veiligheid en talentontwikkeling te vergroten en hiermee indirect de sociaaleconomische ongelijkheden bij de jeugd (0- tot 18- jarigen) in Rotterdam te verminderen. Het programma bestaat uit samenwerking met stakeholders uit de wijk, op data gebaseerde prioriteiten stellen, op kennis en theorie gebaseerd beleid en implementatie van effectieve interventies.

**Hoofdstuk 9** bevat de effectevaluatie van de wijkprogrammering in het Rotterdamse Kansrijk Opgroeien programma bij 0 tot 12-jarigen. Het programma is uitgevoerd in drie interventiewijken die zijn vergeleken met die controlewijken in Rotterdam. De effectevaluatie had een quasi-experimenteel design met een nulmeting in 2018 en een nameting in 2021. De effectevaluatie is onderzocht op informele opvoedondersteuning, buitenspelen, lidmaatschap van sportclubs, algemene gezondheid, en risico op psychosociale problemen. Twee jaar na implementatie was er een positief interventie-effect op buitenspelen van de wijkprogrammering in het Rotterdamse Kansrijk Opgroeien programma. Verder onderzoek is nodig met behulp van meerdere vervolgmetingen of langere vervolgperiodes, omdat de interventie-effecten mogelijk een langere interventieperiode nodig hebben om effectiever te zijn. Dit wordt ook aanbevolen voor andere programma's die gebaseerd zijn op samenwerking in lokale gemeenschappen. De effectiviteit van dit specifieke op samenwerking gebaseerde programma bij jongeren van 12 jaar of ouder is nog niet geëvalueerd. Door hiernaast ook te kijken naar het implementatieproces van zulke programma uit andere perspectieven, zoals interviews met beleidsmakers of inhoudsanalyses van beleidsdocumenten, zal meer inzicht worden verkregen in onderliggende mechanismen. Verdere verbetering van het programma is nodig.

**Hoofdstuk 10** bevat de discussie met een interpretatie van de bevindingen, methodologische overwegingen en aanbevelingen voor toekomstig onderzoek en voor lokale publieke gezondheid. De volgende conclusies kunnen worden getrokken op basis van de studies die in de proefschrift zijn opgenomen.

Het doel van dit proefschrift was tweeledig. Het eerste doel was om bij te dragen aan de kennis over de gezondheid en het welzijn van kinderen en adolescenten door gezondheidsuitkomsten en hun beschermende en risicofactoren te bestuderen. Het tweede doel was om bij te dragen aan de kennis over effectieve interventies, beleid en beleidsprogramma's ter bevordering van een gezonde leefstijl, gezondheid en welzijn van kinderen en adolescenten.

We vonden dat verschillende sociaaleconomische statusindicatoren en migratiestatus geassocieerd waren met drie gezondheidsuitkomsten (d.w.z. een relatief hoger risico op een lage groenteconsumptie, een relatief hoger risico op een lage fruitconsumptie en een relatief hoger risico op psychosociale problemen) bij kinderen van 4 tot 12 jaar oud. Niet alle waren echter relevant voor elk type gezondheidsuitkomst. Aangezien verschillende paden kunnen leiden tot sociaaleconomische ongelijkheden op het gebied van gezondheid, moet zorgvuldig worden overwogen op welke groepen interventies, beleid en beleidsprogramma's moeten worden afgestemd en gericht.

We vonden aanwijzingen voor beschermende en risicofactoren voor de psychosociale gezondheid van kinderen en adolescenten en voor vertrouwen van ouders in de eigen opvoedcompetenties. Deelname aan georganiseerde sport en non-sport activiteiten kan een beschermende factor zijn voor de psychosociale gezondheid van kinderen en adolescenten. Deelname aan meer categorieën van georganiseerde activiteiten in vergelijking met deelname aan één categorie van georganiseerde activiteiten kan mogelijk nog meer beschermend werken. Verder vonden we mogelijke beschermende (opvoedtevredenheid van de moeder, ervaren sociale steun en huishoudinkomen) en risicofactoren (opvoedstress, depressie van de moeder en temperament van het kind) voor vertrouwen van ouders in de eigen opvoedcompetenties. Deze inzichten over beschermende en risicofactoren kunnen worden gebruikt voor preventie interventies, beleidsprogramma's en beleid op lokaal niveau.

We hebben bijgedragen aan de kennis over effectieve interventies, beleid en beleidsprogramma's die gericht waren op het bevorderen van de gezondheid en het welzijn van kinderen en adolescenten. We hebben bewijs gevonden voor effectieve interventies om de waterconsumptie te verhogen bij kinderen in de peuter- en basisschoolleeftijd. Interventies waren het meest effectief als ze zich uitsluitend richtten op voedingsgedrag of drinken en als interventies thuis of in de gemeenschap werden uitgevoerd in plaats van op school. Na een periode van twee jaar leverde het programma Kansrijk Opgroeien een positief interventie- effect op één van de uitkomsten (buitenspelen). Verdere doorontwikkeling van het programma is nodig.

Dit proefschrift heeft inzicht opgeleverd over de associatie van verschillende aspecten van sociaaleconomische status met specifieke gezondheidsuitkomsten. Ook is meer inzicht vergaard over beschermende en risicofactoren die belangrijk zijn voor gezondheidsuitkomsten en voor de effectiviteit van interventies op het gebied van publieke gezondheidszorg. Onderzoek op het terrein van publieke gezondheid kan bijdragen aan verbetering van lokale interventies, beleid en beleidsprogramma's ter bevordering van de gezondheid en het welzijn van kinderen en adolescenten.

# LIST OF PUBLICATIONS

## This thesis

### *Chapter 2*

**Boelens M**, Raat H, Wijtzes AI, Schouten GM, Windhorst DA, Jansen W. Associations of socioeconomic status indicators and migrant status with risk of a low vegetable and fruit consumption in children. SSM Popul Health. 2022;17:101039.

### *Chapter 3*

**Boelens M**, Raat H, Yang-Huang J, Schouten GM, van Grieken A, Jansen W. Independent contributions of family and neighbourhood indicators of socioeconomic status and migrant status to risk of mental health problems in 4-12 year old children. SSM Popul Health. 2020;12:100675.

### *Chapter 4*

**Boelens M**, Smit MS, Raat H, Bramer WM, Jansen W. Impact of organized activities on mental health in children and adolescents: An umbrella review. Prev Med Rep. 2022;25:101687.

### *Chapter 5*

**Boelens M**, Smit MS, Windhorst DA, Jonkman HJ, Hosman CMH, Raat H, Jansen W. Associations of organized activities with risk of mental health problems in children. (Submitted)

### *Chapter 6*

Fang Y, **Boelens M**, Windhorst DA, Raat H, van Grieken A. Factors associated with parenting self-efficacy: A systematic review. J Adv Nurs. 2021;77(6):2641-61. JIF Q1; JIF=3.2; top 10%

### *Chapter 7*

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### *Chapter 8*

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### *Chapter 9*

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Croll PH*, **Boelens M***, Vernooij MW, van de Rest O, Zillikens MC, Ikram MA, et al. Associations of vitamin D deficiency with MRI markers of brain health in a community sample. Clin Nutr. 2021;40(1):72-8. JIF Q1; JIF=7.3 top 10% *Both authors contributed equally

**Boelens M**, Croll PH, Voortman T. Response letter to the editor: Associations of vitamin D deficiency with MRI markers of brain health in a community sample. Clin Nutr. 2021;40(8):5008. JIF Q1; JIF=7.3 top 10%

Yang-Huang J, van Grieken A, You Y, Jaddoe VWV, Steegers EA, Duijts L, **Boelens M**, Jansen W, Raat H. Changes in Family Poverty Status and Child Health. Pediatrics. 2021;147(4). JIF Q1; JIF=7.1 top 5%

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Smit MS, **Boelens M**, Mölenberg FJM, Raat H, Jansen W. The long-term effects of primary school-based obesity prevention interventions in children: A systematic review and meta-analysis. (Submitted)

## ABOUT THE AUTHOR

Mirte Boelens was born on April 7th in 1993 in Zuidwolde (Bedum), the Netherlands. She studied Nutrition and Dietetics at the Hanze University of Applied Sciences in Groningen. She conducted a bachelor thesis about the vitamin C status in chronic kidney disease patients at the University Medical Center Groningen. After obtaining her bachelor degree in 2016, she continued with the master Nutrition & Health at Wageningen University. She completed a specialization in Epidemiology & Public Health. Her thesis was about dietary fiber consumption and coronary heart disease and ischemic heart disease in elderly post-myocardial infarction patients. As part of this master Mirte also conducted a research internship at the Epidemiology department of the Erasmus University Medical Center Rotterdam about vitamin D and MRI markers of brain health in 2018. She wrote a paper about this study which was later submitted and published.

After graduation of the master, she stayed at the Erasmus University Medical Center Rotterdam. She started working as a PhD candidate at the department of Public Health in July 2018. As a PhD candidate she coordinated a mixed-methods evaluation study of a collaborative community-based program implemented in neighbourhoods Rotterdam. This project, called Promising Neighbourhoods, included qualitative research such as focus groups and included quantitative research.

Besides this project she was also involved in other projects about youth health care and lifestyle. Further, she was involved in teaching such as supervising medical students with their community projects and with their thesis. She also lectured medical students about lifestyle and prevention and psychological communication skills.

Mirte was also involved in several other activities. She was part of the JVO (Junior representatives of the department of public Health) in 2018-2021. In 2020, she also joined the Rotterdam Science Café which aims to enable dialogue between the general public and researchers by inviting researchers to present their research in an informal café setting. Finally, after she left the JVO, Mirte became active as a committee member for Junior Epidemiologists at the Dutch Society for Epidemiology. This committee organizes seminars, lectures and symposia.

## PHD PORTFOLIO

Name: Mirte Boelens
Erasmus MC department: Public Health
Research school: Netherlands Institute for Health Sciences (NIHES)
PhD period: 2018-2022
Promotor: Prof. dr. H. Raat
Copromotor: dr. ir. W Jansen

| 1. PhD training | Year | Workload (ECTS) |
|---|---|---|
| **Courses** | | |
| PhD introduction session | 2018 | 0.2 |
| Principles of Research in Medicine and Epidemiology | 2018 | 0.7 |
| Methods of Public Health Research | 2018 | 0.7 |
| Introduction to Global Public Health | 2018 | 0.7 |
| Primary and Secondary Prevention Research | 2018 | 0.7 |
| Methods of Health Services Research | 2018 | 0.7 |
| Social Epidemiology | 2018 | 0.7 |
| Erasmus Summer Lectures | 2018 | 0.4 |
| Endnote course, Medical library, Erasmus MC | 2018 | 0.1 |
| Workshops medical library: systematic literature research PubMed 1 & 2 | 2019 | 0.2 |
| Logistic Regression | 2019 | 1.4 |
| Regression Analysis | 2019 | 1.9 |
| Erasmus Summer Lectures | 2019 | 0.4 |
| Introduction Course NVivo | 2019 | 0.3 |
| Data visualization with R | 2019 | 0.4 |
| Introduction to Bayesian Methods in Clinical Research | 2020 | 1.4 |
| Causal Mediation Analysis | 2020 | 1.4 |
| TTT1 (BKO) | 2020 | 0.3 |
| Workshops medical library: Systematic literature retrieval Embase and reviews Project Management multiple database and Endnote | 2020 | 0.2 |
| Scientific integrity | 2021 | 0.3 |
| Maternal and Child Health | 2021 | 0.9 |
| Biomedical Writing for PhD Candidates | 2021 | 1.5 |
| Personal Leadership & Communication | 2021 | 1.0 |

| | | |
|---|---|---|
| Flipping the Classroom | 2021 | 0.3 |
| Developing e-modules | 2021 | 0.3 |
| **Presentations, conferences, meetings and seminars** | | |
| Participation Voor de Jeugd Dag | 2018 | 0.3 |
| Oral and poster presentation at the European Union for School and University Health and Medicine (EUSUHM) conference, Rotterdam | 019 | 1.0 |
| Workshop Kennisfestival Municipality of Rotterdam | 2019 | 1.0 |
| Oral presentation ZonMw project leader meeting, Utrecht | 2019 | 0.2 |
| Oral presentation ZonMw expert meeting, the Hague | 2019 | 0.3 |
| Oral presentation SEGV Symposium, Amsterdam UMC | 2020 | 0.5 |
| Oral Presentation Voor de Jeugd Dag | 2020 | 1.0 |
| Poster presentation INRICH, Rotterdam | 2021 | 0.5 |
| Oral Presentation at a research meeting for the department of Public Health, Rotterdam | 2021 | 0.5 |
| Seminars at the department of Public Health | 2018-2022 | 2 |
| Section meetings of the Youth Health Care section | 2018-2022 | 2 |
| Research colloquium meeting of Youth Health Care section | 2018-2022 | 0.5 |

| **2. Teaching** | **Year** | **Workload (ECTS)** |
|---|---|---|
| Revising/grading bachelor essays BSc. Medical students | 2019 | 1.0 |
| Revising/grading bachelor essays BSc. Medical students | 2020 | 1.0 |
| Supervising community projects BSc. medical students minor Public Health | 2020 | 0.5 |
| Teaching GVO education for medical students | 2021 | 0.2 |
| Supervising MSc. Medical student with thesis | 2021-2022 | 0.5 |

| **3. Other activities** | **Year** | **Workload (ECTS)** |
|---|---|---|
| Organization of section meetings and research colloquia meetings | 2018-2020 | 3.0 |
| Secretary/and organizer of events of the junior research representatives (JVO) | 2019-2021 | 1.5 |
| Chair and PR of the Science café (Wetenschapscafé) Rotterdam | 2020-2022 | 1 |
| Member of the Junior epidemiologists committee (Werkgroep junior epidemiologen Vereniging voor Epidemiologie) | 2021-2022 | 1 |
| Peer review for Health & Place and Social Science and Medicine | 2020-2021 | 0.5 |

*1 ECTS (European Credit Transfer System) is equal to a workload of 28 hours.

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