UiT The Arctic University of Norway

Faculty of Health Sciences – The Department of Community Medicine

Overweight and obesity among children – Is there an association between school provided meals and BMI changes?

Mikaela Reinikainen

Master's thesis in Public Health, HEL-3950, December 2022

Supervisor: Tiina Ikäheimo, PhD, Professor, UiT Department of Community Medicine

Co-supervisor: Ane Kokkvoll, PhD, UiT

Abstract

Background: Overweight and obesity has become a worldwide problem in the last decades. Among children aged 5-19, overweight and obesity prevalence has risen from 4% in 1975 to 18% in 2016. Children with overweight and obesity are also more likely to stay obese into adulthood. The consequences of being overweight and obese in childhood increases the risk of several non-communicable diseases and early morbidity. For children, school is a place where they spend most of the time during the day and consume one to two meals during the school day. Provided school meals play an important role in the overall health of children and their learning outcomes. While Norway is gradually preparing to include provided school lunches to all students, more evidence is needed of the impact of school meals on children´s wellbeing ang weight outcomes.

Objective: The aim of this study is to assess if there is an association between school provided meals and weight change in school-aged children.

Methods: This systematic review followed the PRISMA guidelines. The literature search was conducted utilizing four different databases: PubMed, Medline, CINAHL and Embase. The keywords of the search strategy were based on MESH terms. PICO criteria were used to identify the studies. Inclusion and exclusion criteria were defined and applied. The JBI critical appraisal tool was used for the included studies. After the screening process, 16 studies were included in this systematic review. 15 of the studies were conducted in United States, and one in the UK.

Results: Changes of BMI are not alone related to school provided meals. Several factors as ethnicity, gender differences, SES, and other family characteristics showed to have influence on the association between school provided meals and BMI.

Conclusions: School provided meals do not alone affect BMI among children but contribute to improving health and reducing social and health inequalities among children.

Acknowledgements

It has been such a pleasure and interesting journey to be an MPH student at The Artic University of Norway. Covid-19 pandemic and its impact on the studies and my work as a public health nurse has made my journey as an MPH student more interesting and challenging. I want to thank my colleagues at work and Kåfjord Municipality in Norway for the possibility to take part in the studies.

Unfortunately, the war continues in Ukraine and the coronavirus is still circulating. These new crises have had and will influence global health. Also, overweight and obesity among children is still a relevant theme and will have an impact on global health and wellbeing in the future.

I would like to thank my supervisors Tiina Ikäheimo and Ane Kokkvoll for their advice and guidance. I would also like to thank research librarian Dr. Eirik Reierth for all useful tips and wonderful guidance.

I am more than grateful to my fellow students L.Nevala and J.Sanoja for motivation, support and kindness. Without these two, I would have been so lost during these studies.

The last year has been an extremely challenging time to me and my family. I am very grateful for my sisters, brothers, mother, stepfather, and closest friends who have been supporting me all the way through the studies and helping me with my little daughter during this busy time. Without these people, neither this thesis nor these studies would have been completed.

I would like to express especial gratitude to my strong, inspirational mother who was living one week at a time since January 2022, after being diagnosed with an incurable cancer. Even she didn´t have that much time left, she fought and cheered me until the end. My mom lost her fight, but luckily one of my brothers is back alive from fighting in Ukraine.

Finally, the last special thoughts go to my little girl, who makes me smile every day.

Table of Contents

List of Tables

List of Figures

Abbreviations

BMI	Body mass index
CDC	Centers for disease Control and Prevention
CDS data	Child Development Supplement
ECLS-K	Early Childhood Longitudinal Study Series, kindergarten cohort.
FRP	Free- or reduced- price
FNS	The Food and Nutrition Service
HHFK	Healthy Hunger free kids act
IOTF	International obesity task force
NCD	Non-communicable disease
NSCH	National Survey of Children´s Health
NSLP	National lunch program
NCMP	National Child Measurements Program
OWOB	Overweight and obesity
PSID	Panel study of income dynamics
SBP	School breakfast program
SES	Socioeconomic status
SNDA-III	School Nutrition Dietary Assessment Study – III
SR	Systematic review
UFM	Universal free meals
UIFSM	Universal free school meals
UK	United Kingdom
USDA	U.S. Department of agriculture
U.S.	United States of America
WHO	World Health Organization

1 Introduction

In Norway, a nationwide dietary survey showed that Norwegian children and adolescent have a high intake of saturated fat and added sugar, and low intake of vegetables, fruits and fish compared to dietary recommendations (1). It has also been reported that Norwegian children and adolescents have a high intake of unhealthy snacks (2). Nutritional experts have pointed out that municipalities should have more attention on following national dietary guidance and policies in the kindergartens and schools to improve children´s nutritional needs. Currently, the government of Norway will gradually introduce a healthy school meal to all children. Ultimately, politicians are those who will decide how and where to invest the money (3). Providing free school meals in Norway has been a political debate in recent years, and several political parties have promised to introduce healthy school meals to schools in the year 2019. At present, Norwegian children mainly bring their school meals from home, but several municipalities have started to provide simple cold meals (bread) one to five times per week. Approximately 16% of lower secondary schools had any school meal program, and only 6% had a school provided free meal every day during spring 2020 (4). For the last eight years working as a public health nurse in Northern Norway, I have been interested in how healthy school meals could improve the overall health and academic performance of school children. That's the reason for this subject on my thesis.

1.1 Background

For children, school is one of the places where they spend most of the time during the day and consume one to two meals during the school day. Schools should also be one of the places where children have an opportunity to learn about healthy lifestyle choices. According to previous studies, free healthy school meals could contribute to an overall healthy diet and reduce social health inequalities (5). However, the school lunch practices and provision of meals vary by country. In the Nordic countries, only Finland and Sweden provide free hot meals in schools for lunch to all children irrespective of the family´s financial situation. In Iceland school meals are partly paid by the families and partly by municipalities, but home packet lunches are also an option (6). Otherwise in the Nordic countries, school children mainly have packed lunch from home (7-9). In the U.S. the National lunch program (NSLP) provides low-cost or free

lunches in 100,000 public and nonprofit schools. In 2020, 22.6 million children participated in the NSLP. In addition, the school breakfast program (SBP) provided free or low-cost breakfast approximately to 12.4 million children each school day in the year 2020. These programs are administered by U.S. Department of Agriculture, USDA. (10) In the UK, the Universal Infant Free School Meal (UIFSM), a program implemented in 2014, serves free lunches to children aged 4-7 in state-funded schools for the first three years of schooling (11). In Japan school lunches are provided in return for payment in 99.2% of compulsory schools and where families of low-income can receive financial support (12).

Overweight and obesity (OWOB) has become a serious topic, and rather than only affecting high-income countries, the prevalence is rising globally. This global problem involves strong risk factors for developing non-communicable diseases, and is one of the reasons for early morbidity and mortality. Approximately 2.6 million people die every year as a result of being overweight or obese, and these conditions are thought to be one of the most serious public health challenges of the 21st century (13).

Among children aged 5-19, OWOB prevalence has increased from 4% in 1975 to 18% in 2016 (13). The consequences of this can be very serious and associated with several physical problems. OWOB children are more likely to stay obese into adulthood and have an increased risk to develop chronic diseases, such as diabetes, cardiovascular diseases and musculoskeletal problems. In addition, OWOB among children is associated to suffering more often of low self-esteem, bullying, depression, loneliness and sadness (14).

1.2 Factors related to obesity

The main reason for OWOB is the energy imbalance of calorie intake and consumption. Overweight and obesity are defined as a abnormal high fat accumulation that may cause health problems (15). Body mass index (BMI) can indicate OWOB, and is a practical method for screening for weight categories. BMI is calculated as a persons´s weight in kilograms divided by the square of height in meters (16).

According to the World Health Organization (15) BMI of 25 indicates overweight, 30 obesity and BMI of 35 severe obesity in adults (15). When defining OWOB among

children, their age, sex, weight and height need to be taken into account. For this purpose, International Obesity Task Force (IOTF) has created charts for weight limit values to indicate overweight and obesity among children of different ages. IOTF has often been used in studies and especially by Norwegian health care (15,16). Also, WHO Growth Rerefence median and BMI z-score are used to indicate weight deviation among children (16). Children aged 5 to 19 years are defined as being overweight when their BMI is above one standard deviation, and obese when their BMI is above two standard deviations of the WHO Growth Rerefence median (15, 17, 18).

Overweight is preventable, and the related risk factors are easier to control in countries with a well-functioning health care system with regular monitoring and screening capacity. The Nordic countries have a very similar health care system and national guidelines to be followed by health care workers. Children are called to regular screenings at different ages from birth to age 18. These contain weight and height monitoring, and dietary guidance (19). Despite the efficient health care system in the Nordic countries, the trend of OVOB among children is resembling those of other countries on a global scale.

According to the studies and statistics, the prevalence of OVOB among children is higher in rural than urban districts in the Nordic countries (20). Overweight and obesity prevalence among children is similar in Norway and Finland, where the health care systems are quite similar, but where there are differences in school-lunch practices. Overweight and obesity among children and adolescent is a very complex problem and includes other factors in addition to an unhealthy-diet, such as lack of physical activity, social structures, and influence of genetic factors. In addition, many children have lack of resources, education or support outside of their home (21, 22).

Diet alone does not result in overweight, and is not as such the only solution for effective weight control programs. Physical activity also plays an important role in health and wellbeing. A systematic review that examined interventions for preventing obesity in children found that physical activity can independently reduce the risk of obesity in children and adolescent aged 6 to 18 years. Diet combined with physical activity may as well be effective. In contrast, results from interventions involving only dietary changes found little or no impact on BMI (23). Another systematic review found strong evidence that physical activity interventions at schools alone or with home

involvement, or combined diet-physical activity interventions, prevented childhood obesity (24). Race, gender, culture, and environment are influential factors for childhood overweight and obesity, suggesting that some of the populations are more vulnerable to develop overweight and obesity. Low socioeconomic status reflects social inequalities in diets. Basically, those who are more vulnerable for poorer diet and weight gain, should receive more focus and support for prevention and management of overweight (5, 25).

Several studies have been conducted to examine the relationship between school provided meals and children's weight status and BMI. Most of these consider NSLP and SBP programs in the US. In 2010, the nutrition standards for U.S. school meals were updated after the implementation of the Healthy, Hunger-Free Kids Act initiated by the US Department of Agriculture. The new nutrition standards were implemented in schools in 2012-2013 (26). The results following the update of the nutrition standards showed that school meals of higher nutritional quality may contribute to reduced weight and increased health status of children who participated in NSLP (9, 27, 28). In addition, a few studies showed that children who eat school provided meals had a more nutritious lunch compared to children with home-packed lunch (28-30).

The hypothesis of this thesis is that offering high-quality school meals for free or with reduced price can improve health dietary intake and thereby have a positive effect on reducing children´s BMI on the long run.

1.2.1 The research question and aim

The aim of this study is to assess if there is an association between school provided meals and weight change in school-age children.

The research question of this study:

Is there an association between school provided meals and BMI changes in school aged children?

2 Methodology

2.1 Study design

This study is a systematic review, and it is conducted in accordance with PRISMA (Preferred Reporting Items for Systematic Review and Meta-analyses) guidelines (31).

2.2 Eligibility criteria

2.2.1 PICO criteria

PICO (Population, Intervention/Exposure, Comparison and Outcome) criteria were applied to identify relevant studies for this systematic review to address the research question. The population of interest was children attending elementary school. The intervention group focused on children who were served free or reduced-price lunch at school. The comparison group was children who were given home-packed lunch. The outcome of interest is BMI, BMI change, BMI z-score, weight gain or weight loss.

Table 1.PICO criteria applied in this study.

Population	Intervention	Comparison	Outcome
Children aged 4 - 18 years	School provided meals/lunch, free or reduced price scool lunch	Home-packed school lunch Nonparticipant of school provided meals	BMI,BMI-change, BMI z-score, weight gain, weight loss

2.2.2 Inclusion and exclusion criteria

Studies that are included in this systematic review (SR) examine children attending elementary school or pre-school at kindergarden. Studies evaluating the relationship between school provided meals or home-packed lunch and outcome of BMI, BMI z-score, BMI change, weight gain or weight loss were included in the SR. This SR includes cohort studies with either cross-sectional, quasi-experimental or longitudinal study design.

For longitudinal studies involving an intervention, a follow-up time of six or more months was set as a requirement to be included in this systematic review (32), to be able to observe an effect on BMI (18). To minimize heterogeneity due to the influence of culture and economical differences on dietary behavior, this SR only includes

studies conducted in high-income countries. List of studies included in this SR is provided in Appendix 1. Published full text articles in English, Finnish, Swedish or Norwegian language were included.

Studies were excluded from the SR if they did not meet the criteria of the population of interest, children aged <4 and >18 years. Studies that did not include the outcome criteria of effect of school provided lunches on weight, or reported outcomes focused only on nutritional contents or physical activity without BMI/weight outcomes, were excluded. Also, studies with missing full text were excluded. Studies published earlier than the past 15 years (before 2007) were excluded.

2.3 Literature search strategy

The SR was conducted utilizing four different databases: PubMed, Medline, CINAHL and Embase. The keywords of the search strategy were based on Medical Subject Headings (MeSH) terms. The following search terms were used; school meal, school provided meal, school lunch, BMI, BMI z-score, BMI, SDS, body mass index, weight change, weight gain, children, adolescent.

Boolean operators “AND” and “OR” for filtering searches were used. Search terms for school meal, school provided meal, school lunch and school meals were combined with “OR”. Search terms for BMI, BMI z-score, BMI, SDS, body mass index, weight change or weight gain were combined with “OR”. Search terms for school aged children, children and adolescents were combined with “OR”. These three different search terms themselves were combined with “AND”. The studies were filtered to include only human studies, specified publication year and full text publications. Search was started during the autumn 2021, and the last search was done by the end of the April 2022. A research librarian was consulted to confirm that the right literature search strategy was used.

Hand-searching was conducted of selected studies that met the inclusion criteria to ensure that no relevant articles were missed. Hand-searching was done by screening through references of selected studies.

2.4 Selection process and data collection

The selection process and data collection were done by the author. At the first phase retrieved titles were independently checked from all the identified records to exclude studies that were not relevant to the research question, and any duplicates were removed from the literature search.

Second, screening of the abstracts led to exclusion of studies if they did not meet the inclusion criteria. Further screening was based on careful examination of full articles of the selected studies. Systematic reviews, studies that had too short follow-up time, “gray” literature (one master thesis), or outcomes that did not meet the research question were excluded. Critical appraisals of the selected studies were conducted by two student colleagues in addition to author before confirming their final eligibility to this systematic review.

2.5 Data extraction

A table sheet was developed to extract data from the included studies. The following data was collected from each of the included study: authors, year of publication, country, study design and data that been used. Studies were also identified by numbers to facilitate their handling during the process. The characteristics of the included studies are presented in Table 2 and Table 3.

2.6 Quality assessment of selected studies – risk of bias assessment

The quality assessment was done by author and two students colleagues. The quality assesment/critical appraisals were conducted on all of the selected studies by both the author and the student colleagues, to provide two assessments of each study. The studies were distributed randomly to the fellow students by casting lots, and both student colleagues provided eight guality assessments each.

We used The Joanna Briggs Institute critical appraisal tools that are designed for improving healthcare practice and health outcomes (33). JBI has several critical appraisal tools, designed for various study designs that were also used in this review. The aim of these appraisals is to assess the methodological quality of a study, and to find possibe bias in design, conduct or analysis. The critical appraisal tool for cohort

studies include eight questions for determining bias of the study. Cross-sectional critical appraisals tools include 11, and quasi-expermiental nine questions.

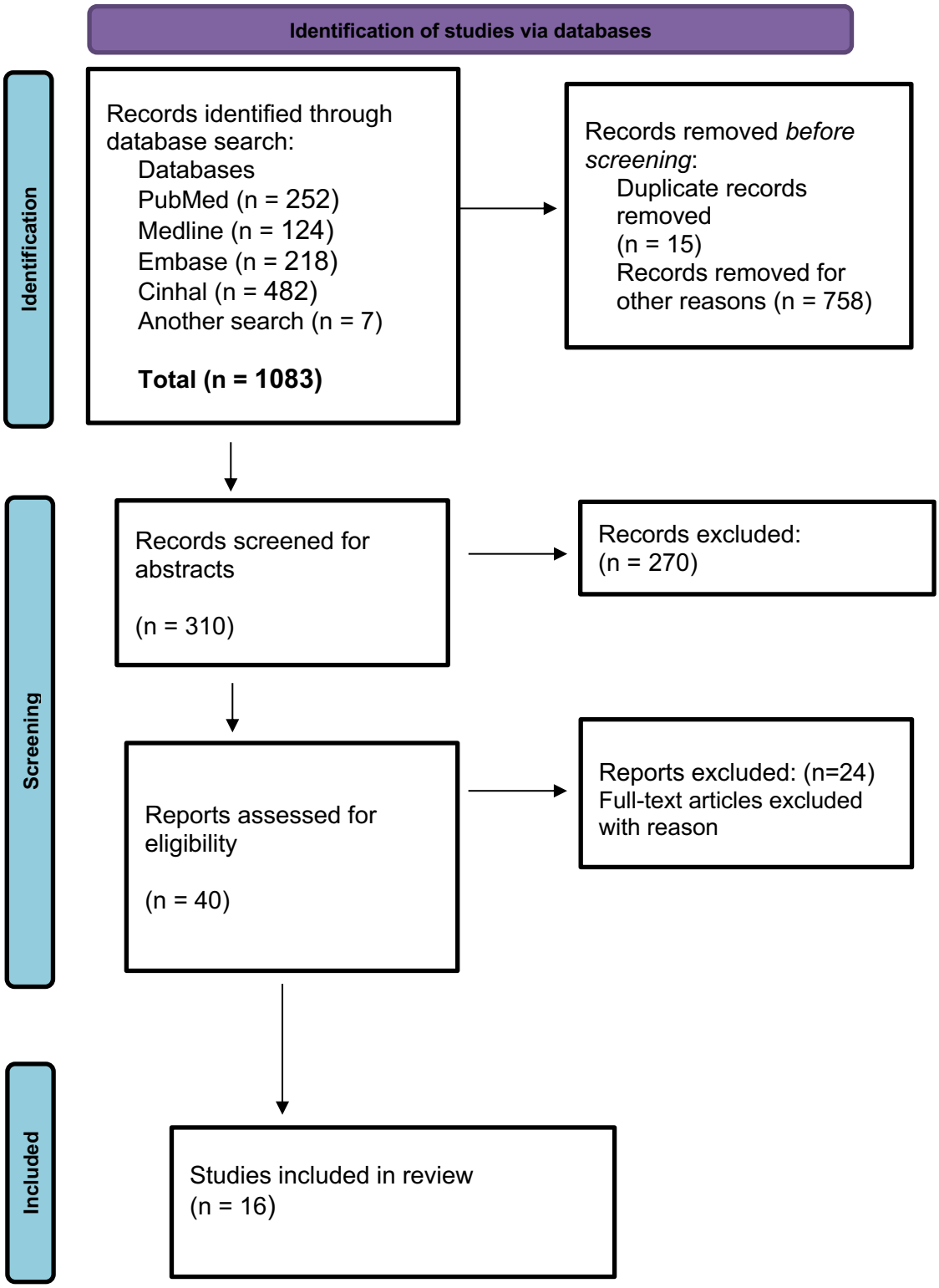

Figure 1. Summary of the literature search.

2.8 Description of the included studies

A total of 16 studies were included in this SR. 13 of the included studies were cohort studies, which of six had longitudinal cohort study design. Two of the of the included studies were cross-sectional studies and one quasi-experimental intervention study. All studies, except one from the UK, were conducted in the U.S. The studies from U.S examined association between school meal participation and BMI. Children who participated in the studies were children who were eligible for free school meals, and the studies examined association between participation in NSLP/SBP and BMI. Two of the studies were targeted to study children from low income families (34, 35).

Most of the studies included participation to a school breakfast program as an intervention, in addition to school lunch program. Focus on this thesis was the association of participation on school lunch and its relationship to BMI or weight outcomes. In the U.S there are different kind of school meal practices. One of the mostly examined practices in the included studies is the participation in National School Lunch program NSLP and/or school breakfast program SBP. One study examined the impact of Universal Free meals UFM, which has been adopted in schools and district in the U.S. The UFM program provides free lunch and breakfast for all, irrespective of the family´s financial situation (36). Two of the included studies examined reasons for the relationship between school meals participations and BMI outcomes.

Most of the studies have been conducted before the implementation of USDA updated nutrition standards. These new updated nutrition standards were implemented in the school year 2012-2013. The effects of the new guidelines vary at national level, as the decision for changes has been made by local school districts, and the effect can't be observed in studies that were conducted before (37).

Table 2. Characteristics of the included studies.

ID nr.	Author	Year	Location	Study Design	Data
1.	Gleason et al.	2009	USA	Cohort	SNDA-III
2.	Schanzenbach	2009	USA	Panel, cross-sectional	ECLS-K
3.	Ji Li et al.	2010	USA	Cross-sectional	NSCH, years 2003-2004
4.	Baxter, Hardin et al.	2010	USA	Cohort	Years 2004 - 2007
5.	Millimet et al.	2010	USA	Cohort, panel study, longitudinal	ECLS-K
6.	Hernandez et.al	2013	USA	Cohort, longitudinal	ECLS-K
7.	Paxton, Baxter et al.	2012	USA	Cohort	Data from four cross-sectional studies.
8.	Guinn et al.	2013	USA,	Cohort, longitudinal	Years 2004-2007
9.	Baxter, Paxton-Aiken et al.	2012	USA	Cohort	Data from four cross-sectional studies
10.	Mirtcheva et al.	2013	USA	Cohort, longitudinal	PSID – CDS, from 1997 to 2003
11.	Capogrossi et al.	2017	USA	Cohort, longitudinal	ECLS-K
12.	Vericker et al.	2019	USA	Quasi-experimental, intervention, longitudinal	ECLS-K
13.	Kenney et al.	2020	USA	Cohort	NSCH
14.	Bardin et al.	2020	USA	Cohort	SNMCS, 2014-2015
15.	Schwartz et al.	2020	USA	Cohort, longitudinal	Student Level Data, 2010-2013
16.	Holford et al.	2022	UK	Cohort	NCMP, from 2008 to 2018

2.8.1 Description of data

The data that has been used in the included studies contains similar information about children´s health and households characteristics. Five of the included studies have used data from the ECLS-K (Early Childhood Longitudinal Study Series, a kindergarten cohort data) program. The program includes two longitudinal studies that examine child development, school readiness and early school experiences. The kindergarten cohort class of 1998-1999 is a sample of children followed from kindergarten through the eighth grade. The data includes a sample of 21,260 children from years 1998-1999 and up to 2006-2007, and has been conducted in over 1000 different schools, collecting a wide range of information on children, their families, and schools (38).

Two of the studies used the National Survey of Children´s Health (NSCH) data. NSCH provides information on children´s physical and mental health. NSCH data that was used in one of the included studies by Ji Li et al., conducted the study by a telephone survey repeated three times between 2003 and 2012. Kenney et al. used NSCH data from 2003 to 2018 (39).

Child Development Supplement (CDS) is one of the components of the Panel Study of Income Dynamics (PSID). PSID includes a sample of 18,000 people in 5,000 households and provides data on children and their families. It includes a wide range of questionnaire information of family's employment status, income, expenditures, and wealth. The CDS study collected information from parents and children according to the age-graded assessment of cognitive, behavioral and health status (40).

The third School Nutrition Dietary Assessment study (SNDA-III) was used in one of the included studies. SNDA-III data is representative of all public-school students during school years 2004-2005. The sample is collected from grade 1st to 12th and includes 2,314 randomly selected children. Each sample includes twenty-four-hour dietary recalls along with student and parent surveys. The surveys include questions related to participation in NSLP/SBP, and characteristics of demographic and socioeconomic status such as a sex, ethnicity, family income, family structure, parent's employment status and education level. In addition, the study includes questions of the children´s physical activity level, eating habits and other lifestyle habits such as watching TV and computer use. Weight and height of the children were measured by the study team. Parents were interviewed in person or by telephone, depending on the child´s age (41).

The School Nutrition and Meal Cost Study data (SNMCS) is a representative sample of 2165 students across 293 public schools. The student´s ages range from 6 to 19 years, and they participated in the NSLP during the school year 2014-2015. SNMC includes information on student demographics, physical activity levels, usual eating habits and household characteristics. The information was collected by interviewing students and parents (28).

Student transaction data is collected by NYC Office of School Food. The data includes information on gender, race, primary language spoken at home, English proficiency,

birth country, validity for free or reduced-price lunch, and participation for school meals. It also includes participation in special education, attendance, some academic scores, and student heigh and weight. The school collected data on participation in school lunch and breakfasts. This data is collected by using an electronic Point-of-Service (POS) tracking system to record meal transactions with student-ID and time stamps (42).

In the UK, National Child Measurements Program NCMP collected data on the height and weight of children in all 16,000 primary schools in England on each school year since the 2005/06. This was the government´s strategy to tackle obesity and to gather population-level data to analyze the trends in growth patterns and obesity (11).

2.9 GRADE assessment

GRADE-guidelines (Grades of Recommendation, Assessment, Development and Evaluation) were used to assess the quality of the studies included in this SR. GRADE method ranks the study quality from very low to low, moderate, or high. Observational studies start at low. There are factors that can either reduce or increase the quality of the evidence. In this thesis the factors that reduced the quality of evidence were due to unclarity of risk of bias, and some serious inconsistency and imprecision of the results.

All the included studies were directly relevant to the SR. The limitation of risk of bias was found in surveys that could not describe clearly how many times children were participating to school meals, and what and how much they ate. Diet or school lunch quality was unclear nearly in all the studies, which makes it difficult to compare the result to the European countries. School meal participation was reported either from none to three or more than three times per week, which can also increase the risk of bias. Studies which had observed participations in school meals by researchers increased the quality of evidence. Measurements that were taken by researchers, in addition to data, increased the quality of evidence as well. Surveys where children´s weight and height were reported by parents were seen as a risk of bias. GRADE assessments for included studies are provided in Table 4.

3 Results

3.1 Results of the literature search

Based on this SR the impact of school provided meals on children´s bodyweight showed diverse results. No association between school-provided meals and BMI was shown in five of the 16 studies. Positive association between school provided meals and BMI was shown in four of the 16 studies. These studies used data before the updated nutrition standards for school meals were implemented in the U.S. Three of the 16 studies were measuring the effect of HFFK updated nutrition standards for school meals and BMI outcomes. The results are divided in four main categories.

3.2 No association between school provided meals and BMI outcomes

Five of the 16 studies found no evidence of a relationship between school meal participation and BMI outcomes. The results of the study by Gleason and Dodd (41) didn´t find evidence that NSLP participation is related to BMI or risk of overweight or obesity. The study had adjusted for confounding factors such as a level of physical activity, screen time, school characteristic, usual eating habits and students' demographic and socioeconomic characteristics. Non-Hispanic black students tended to have higher BMI whereas more active children had lower BMI. Participation in the NSLP, at least three days a week, showed no relationship in weight status. This study also included participation in the SBP. Summarized, the results showed that participation in NSLP did not influence the weight outcomes, but participation in the SBP was estimated to reduce BMI. These results are similar with those reported by Baxter, Hardin et al. (43), who found that daily participation in school provided meals was not significantly associated with BMI. In addition, the study by Hernandez (34) did not detect a change in the average levels of BMI when studying the impact of participating in the NSLP among low-income children. However, when analyzed by gender, participation in NSLP was associated with rapid weight gain among low-income girls but not in boys (34).

Paxton, Baxter (44) et al. examined the relationship between school meals and BMI outcomes using four cross-sectional studies. The results showed that participation to

breakfast, lunch or both were not related to BMI outcomes, but race was related to BMI after accounting for all other variables. In this study BMI was estimated to be greater among black children compared to white. The results are consistent with other studies and show also how age was positively related to BMI increase with one month´s increase in age. The observed energy intake was positively related to BMI for all school provided meals, but gender was not related to BMI in this study (44). The study by Mirtcheva et al. (45) showed that participation in NSLP in public schools increased weight. However, when analyzed separately by gender, the increase in BMI percentile was for girls, but had no effect for boys. Girls who participated to school provided lunch, were on average eight BMI percentiles heavier than non-participating girls. The characteristics for children who participated in NSLP were more likely to be black, Hispanic, have a lower birth weight and less educated mothers. In summary, this study didn´t detect an effect between school lunch and higher weight outcomes (45). The limitation of this study is that the number of times a child ate school provided lunch per week was unknown.

Baxter, Hardin et al. (43) studied the association between BMI and daily participation to school meals and their observed energy intake. The study showed that children having school meals, either breakfast, lunch, or both, had no association to BMI changes. Gleason et al (41) found the similar results, where BMI was not influenced by whether children were participating in one or more school provided meals. The study of Baxter, Hardin et al. (43) showed that children who participated to breakfast were more likely to belong to a higher BMI category for every increase of 100 kilocalories (43).

Although the previous studies did not find an association between the school provided lunches and BMI, some studies related to participation to the SBP show different results. Gleason et al. found that participating to SBP was related to reduced BMI, and where the participating children had a lower BMI than those who did not eat breakfast (41). Baxter, Hardin et al. (43) also found that breakfast location was important when analyzing BMI changes. Children who ate breakfast in the classrooms, were observed to have a higher energy intake than those who ate in the cafeteria (43).

3.3 Positive association between school provided meals and BMI outcomes

Four of the included studies showed that school provided meals were associated with weight gain. Schanzenbach (46) compared children who ate school provided meals with children who brought home-packed lunch. The study found that students who ate school provided meals were more likely to be overweight. These students were 2.4% more likely to be overweight by the end of the first grade and 2% after having school provided meals for two years (46).

The study by Millimet (47) et al. showed that children that participated in both SBP and NSLP are associated with heavier weight on the third grade. Participating in one of the programs increased BMI by 0.6% from the first to third grade. These children were also 3.1% more likely to be overweight on third grade. Only participating in NSLP was associated with an 6.8% increase in probability of being obese on third grade. When entering kindergarten, 11.3% of the children were obese, and on third grade 17.2%. In summary, the results show that children's participation to SBP did not contribute to weight gain, but NSLP may aggravate it. The results concerning the relationship between SBP and BMI is supported by the previously mentioned studies as well (47).

Li et al. (48) found that school type has an impact on BMI, with a stronger effect for lower SES households. Children attending the public school and participating in NSLP or SBP have a higher BMI than their counterparts in the private schools. Children with higher SES, and not eligible for NSLP/SBP, had a higher mean BMI in public compared to private schools. School type did not have a significant effect on the probability of being overweight in the lower SES households. Generally, children that are attending public compared with private schools have higher BMI, regardless of the NSLP or SBP programs. Children who were eligible for the NSLP or SBP have a 4.5% higher probability of being overweight compared to not eligible children (48).

Capogrossi and You W. (35) examined the influence of participation in both school meal programs compared with just one program and followed the weight progress from 1st to 8th grade. The results show that school provided meals increase the probability of higher BMI and risk of being overweight. The results indicate that there was a relationship between meal program participation and higher weight. The impact was

stronger during long-term participation (1st through the 8th grade), than short-term participation (1st to 5th grade). The impacts of school meal programs on weight of the children were most significant in the southern and northeastern regions of the U.S, which may have implemented different practices that could influence the types of food served at school. The probability of being overweight for a child on the 5th grade and who participated in NSLP was larger in the south. Also, participation in both programs in the northeastern region had a significant impact on the 8th grade child´s weight (35).

3.3.1 Factors affecting the positive association between school meals and BMI

Two of the included studies explored the reasons for the positive relationship between participation in school provided meals and BMI. A secondary analysis by Baxter, Paxton-Aiken et al. (49) examined the positive association between BMI and energy intake of school-provided meals among fourth-grade children, and linked these to different explanatory factors. The study found that the average BMI for black children was estimated to be greater compared to white children. BMI was also greater for girls than boys. The influence of daily energy intake of school-provided meals and BMI was stronger for girls and black children. The study also showed that the amounts of school provided meals eaten were positively related to the BMI. When served large portions, children consumed more than when served age-appropriate portions. BMI was negatively related to the energy content given in the food distributions (49).

The study by Guinn et al. (50) also explored the relationship between fourth-grade children´s BMI and the energy intake of school-provided lunch. The purpose of this study was to identify factors that may contribute to the positive relationship between BMI and energy intake related to the study published in 2010 (43). Three of the seven outcome variables were significantly related to BMI. First, BMI increased in relation to the amount eaten per serving of a standardized school meal portion. Secondly, the energy intake of flavored milk increased BMI and children consumed nearly 9-11% of their daily kilocalories from flavored milk at school-provided meals. Third of the significant outcomes was negative relationship between BMI and the energy content given in the food trades which is consistent with the finding of a previous study (50).

3.4 Negative relationship between school provided meals and BMI outcomes

Only two of the included studies found a health effect between school provided meals and BMI. The study from UK by Holford et al. (11) examined Universal Infant Free School Meal (UIFSM) impact to children´s bodyweight. This policy was implemented in the UK in September 2014. The study compared children who participated/were exposed to the school meal policy for different durations with children not exposed to the policy changes. The study found that longer exposure to UIFSM had a beneficial impact on bodyweight. The results showed that the participating children were 1.2% more likely to be healthy weight and 0.7% less likely to be obese, compared to children who were not provided UIFSM. BMI was on average 4.3% of a standard deviation lower among those that participated compared to the non-participants. If expecting that the impact of UIFSM depends on the dose or free meals received, a greater effect should be observed for the children at the end of the first school year. In fact, longer exposure to UIFSM reduced bodyweight (11).

The study by Schwartz and Rothbart (42) examined the impact of the Universal free meals (UFM) on student performance, school meal participation and weight among the New York City middle school students. UFM was provided to all the students regardless of the income status and it increased participation to school lunches by 11% for the non-poor and 5.4% for the poor students. The strongest association between the provided school meal and weight was observed among non-poor students, who showed a 2.5 % decrease in the probability of being obese. At the same time school performance scores increased significantly in math and English language arts both among non-poor and poor students. This study did not detect that the UFM increases the probability of students becoming obese or overweight (42).

3.5 Research findings regarding national improvement in nutrition standards

USDA developed updated the nutrition standards for schools 2010 by the Healthy, Hunger-Free Kids Act (HFFK) which were implemented in the US schools in 2012-2013. Three research studies examined the effects of the updated nutrition standards and weight outcomes after its implementation.

The first study which was conducted to measure the effect of the updated nutrition standards was conducted by Vericker et al. (37). The primary outcome in this study was a difference between BMI z-scores in the third grade and first grade children. This study was examining data before and after the update in nutrition standards. Data from ECLS-K 1999 includes first grade children in 2000, who did not experience school nutrition standards. Data from ECLS-K 2011 includes first grade children in 2012, who experienced effects of a change in nutrition standards. Study compared the weight status of boys and girls of the NSLP participants and nonparticipants in both ECLS-K cohorts (37).

The results showed that BMI z-scores increased between the first and third grade in the primary cohort (ECLS-K 2011) among male NSLP participants and nonparticipants, but the increase in BMI z-score was lower for participants after controlling for other factors. Similar findings were observed for the second cohort (ECLS-K 1999) among boys. Increase was lower for NSLP participants from the primary cohort, who experienced the change in school nutrition standards. According to the results, revised meal standards may improve BMI z-scores for boys but not for girls (37).

The study by Kenney at al. (51) examined whether HHFKA´s revised legislation was associated to reduced childhood obesity risk over time. The data for this study was collected before and after the implementation of the HHFKA legislation. Before HHFKA changes, children living in poverty showed increased odds of being obese per year of follow-up. After HHFKA implementation the odds for obesity were reduced by 9% for each year. This study estimated that after the legislation change there were 500,000 less obese children living in poor families. This could imply a reduction in the risk of future chronic diseases for these children as well as reduced health care cost. However, this study did not find an overall association between the legislation change and childhood obesity trend (51).

The third study that examined the association between weight status and school provided meals after the implementation of the updated nutrition standards were conducted by Bardin and Gola (28). Approximately 25% of the nonparticipants in NSLP

were OWOB and 40% of those who participated for three or more days were identified as OWOB. In summary, there was no difference in the weight status for students who usually participated in the NSLP three or more days per week compared with those who participated less often (28).

Table 3. Characteristics of the included studies and their result.

Author year, location	**Study design Data**	**Participant**	**Intervention Comparison**	**Outcome(s)**	**Results**
1. Gleason et al 2009 USA	*Cohort* Data from SNA-III.	Sample of 2,228 1 st through 12th grade children. Students from school year 2004-2005.	Participation in NSLP and SBP programs. Nonparticipants	Four outcomes' variables, based on student´s measured BMI. BMI z-scores.	No evidence of relationships between school lunch participation and four BMI-related outcomes. School breakfast participation was associated with significantly lower BMI, declined by 0.15 points ($p<0.05$).
2. Schan-zenbach 2009 USA	*Cohort panel and Cross-sectional* Data from ECLS-K study.	Children from kindergarten through eighth grades. Data from 15,000 students, 1000 different schools.	3,295 School lunch participation 1,546 Students who consumed brown bag from home their lunch.	BMI, BMI z-scores Lunch participation status collected from parents	Children who consumed school lunches are two percentage points more likely to be obese compared brown bag- consumers. Though they enter kindergarten with the same obesity rates.
3. Ji Li et al. 2010 USA	*Cross-sectional*. Data from NSCH year 2003-2004	Children aged 6 to 17 years. Totally 62,872 observations of	Participation in NSLP/SBP at public school Participation in NSLP/SBP at private school.	BMI	If child attends public school and is eligible for the NSLP/SBP, BMI is 0,725 ($p<.001$) higher than children attending private schools. Children eligible for NSLP or SBP have a 4.5% higher probability of being overweight.

4. Baxter, Hardin et al. 2010 USA	*Cohort*	Total 1,571 children, observed eating school meals fourth-grade children. (90 % black, 53% girls) Data collected during three school years: 2004-05, 17 schools 2005-06, 17 schools. 2006-05 8 schools South Carolina district.	School lunch participation. Seven of the schools had breakfast in the classroom, all other in the cafeteria. *Observation of school meals intake by research staff.*	BMI *Research staff measured (weight/height) children in the morning after breakfast, but before school lunch.*	Breakfast, lunch participation and combined participation were not significantly associated with BMI. BMI relationship with sex was significant (P<0.001) average BMI for boys 20.56 girls 21.33 BMI related to age was significant (p=0.006) BMI increased by 0.06kg/m as age increased by on month. Breakfast locations was significantly (p=0.012) associated with BMI. Average BMI was higher for children with breakfast in the classroom (21.50) than in cafeteria (20.54).
5. Millimet et al. 2010 USA	Cohort panel study. Longitudinal Data from ECLS-K study.	13,531 children from 994 schools.	3,347 participate in both SBP and NSLP 6,994 participate only NSLP 116 participate only SBP.	BMI, change of BMI percentile	Positive association between participation NSLP and child weight gain, 6.8 percent increase in the probability of being obese in third grade.
6. Hernandez et al. 2013 USA	Cohort Longitudinal, secondary data analysis Data from ECLS-K study	Low-income students totally 1,140 girls n.574, boys n.566	Participation in the NSLP Non-participating in the NSLP	Patterns of NSLP participation. Age- and sex-specific BMI	82% participated in NSLP. 35% persistent, 47% transient. No significant change in average levels of BMI. Results suggest participation in NSLP is associated with rapid weight gain for low-income girls, but not for boys compared to non-participating.

7. Paxton, Baxter et al. 2012 USA	*Cohort* Data from four Cross-sectional studies.	1,535 of children were 51% black, 51% girls. Total 342 children. 54% black, 50% girls. Fourth-grade children, from 6 to 11 elementary school in Augusta, GA. During 4 school years, years 1999 to 2003.	Participation in school meals SBP and lunch (*Direct meal participation of 342 children. Total 1,264 school meals, 50% breakfast)*	BMI *Weight/height measurements by research staff.* *School-meal participation were observed by research staff.*	No significant relationship between school-meal participation and BMI (p> 0.594). Results support a positive relationship between observed energy intake at school meals and BMI increase.
8. Guinn et al. 2013 USA	*Cohort, longitudinal* Cross-sectional study	Of the fourth grade 1,730 children, 465 was randomly selected for meal observation. Data collected during 2004-2007. 1 school district in Columbia, South Carolina	Participation in SBP and NSLP, observed by research staff.	BMI; Weight/height measurements by research staff 1 point of time -Energy content of items selected in kilocalories -Number of meal components selected -Number of meal components eaten -Amounts eaten of standardized school-meal portions -% of energy intake from flavored mil -% of energy intake received in trades	BMI was positively related to energy intake from flavored milk (p=.0041). E*nergy intake of flavored milk increased average BMI by 0.347 kg/m for every 100-kcal.* *BMI* was positively related to amounts eaten of standardized school-meal portions (p<.0001) per serving over both school meals. BMI increased by 8.45 kg/m. BMI was neg. related to energy intake received in trade by decreasing 0.468 kg/m for every 100-kcal increased.
9. Baxter, Paxton-Aiken et al. 2012 USA	*Cohort* Data from 4 cross-sectional studies. Data conducted	328 children, total *1178* school meals, 50%female, 54%black. Fourth-grade children. From 13 schools, 6 to 11 public elementary schools per school	Participation in school-provided meals, breakfast, and lunch.	BMI: *Weight/height measurements conducted by research staff.* Daily energy intake aspects of school meals. -amounts eaten	Daily energy intake at school-provided meals was significantly (P< .0001) related to BMI, the average BMI 0.52 kg/m increased for each 100-kcal increase in intake at school meals. Amounts eaten was significantly (P <.0001) related to BMI. BMI increased 2.98 kg/m on average per 100-kcal increase.

	1999-2000, 2002-03.	year. 1 district in Augusta, Georgia.	*School-meal participation were observed by research staff. 50% breakfast*	-energy content given -energy intake received in food trades -energy intake from flavored milk -energy intake from a la carte ice cream -breakfast type. Sex, age, and race black/white.	Energy content given in food trades was (P=.0052) negatively related to BMI. BMI decreased 1.04 kg/m on average for every 100-kcal given. Sex was significantly (P=.0040) related to BMI, average greater for female. Race was significantly (P=.0002) related to BMI, BMI estimated to be greater for black children 1.62 kg/m. Age and study were not significantly related to BMI.
10. Mirtcheva et al. 2013 USA	Cohort Longitudinal study design. Data from CDS/PSID.	Totally 3,204 children, aged 6 to 18, attending to public schools. Data from 1997 to 2003.	Participation in NSLP Sample of 1,576 observations.	BMI percentile and body weight classification, overweight/obese and obese status. *Weight measurement was from data. Height reported from caregiver in 1997 and measured in person by assessment interview in 2003.*	Basis of the FE results this study does not find evidence that school lunches are related to higher weight outcomes.
11. Capogrossi et al. 2017 USA	Cohort, longitudinal (DID) (ATT) Data from ECLS-K data	Totally 14,710 students included, from 1st through 8th grade. Low-income children eligible for FRP meals. South, Northeast, and rural areas. NSLP	Participation in both NSLP and SBP Participation in only one program	Weight, BMI z-scores *BMI was objectively measured at each data collection point.* *School meals participation status were asked from parents*	Results of DID show that short-term participation (participating NSLP in 5th grade) in only NSLP increases probability to be overweight 0.059 (P=0.03). Participating both program in 8th grade have statically significant increased 0.086 (P=0.04) probability of being overweight and a decreased -0.071 (P=0.04) probability of being healthy weight.

		increases probability ow.			Statistically significant results of ATT show that participation in both program from 1st grade through 8th grade increases the 0.231 probability of being overweight. Participating in only NSLP comparing both programs over the same period having lower (-0.299) probability of being overweight.
12. Vericker et al. 2019 USA	Quasi-experimental intervention, longitudinal Data from ECLS-K	Data from year 1999, 9249 children Data from year 2011, 5480 children.	Participation in NSLP n=5480 Nonparticipants in NSLP n= 9240	BMI z-scores *Heigh and weight assessed from the data.* *NSLP participation status were asked from parents.*	After implementation of updated nutrition standards, boys who participated in NSLP experienced slower BMI z-score growth than nonparticipants. No statistically significant relationship between school lunch participation and BMI z-scores for girls after implementation.
13. Kenney et al. 2020 USA	*Cohort* Data from the NSCH	Children aged 10 to 17 years. Totally 173,013 participants. in all US states and the District of Columbia from 2003 to 2018. Time points before 2003, 2007, 2011- 12 after implementation 2016-2018.	Participation in school meals before the implementation of the HHFKA policies Participation in school meals after the implementation of the HHFKA policies	Obesity, having a BMI above the ninety-fifth percentile. *Parents reported the weight and heigh.*	No significant evidence for a change in the risk of having obesity after implementation (OR:0.98; p> 0.05) For children in poverty, HHFK act was associated with significant reduction in the risk of obesity (OR: 0.91 per year; p= 0.004). *No significant association between legislation and childhood obesity trends overall.*
14. Bardin et al. 2020 USA	Cohort Data from SNMCS	Children aged 6 to 19, Totally 2165 students, across, 293 public schools.	Participating in the NSLP and SBP.	BMI, indicator for overweight and obese. Indicator for obesity.	Participation in the school meal programs has no clear association with student´s weight status.

		Years 2014/15 Valid measurements were of 1963 students.			
15. Schwartz et al. 2020 USA	Cohort, longitudinal Data from student-level data	For all public elementary New York City schools. Elementary and middle school students. Total 645,204 students. Year 2010 to 2013.	Participation in UFM school lunch	Academic outcomes, school meal participation, BMI z-scores	No evidence of increases in average BMI. Some evidence that school lunch improves weight outcomes for non-poor students. No evidence that UFM increases the probability that students are obese or overweight.
16. Holford et al. 2022 UK	Cohort study Collected data from NCMP	Total in 16,000, Children aged 4-5 and 10-11. School years from 2008/09 to 2017/18	Children observed after introducing universal free school meals (UIFSM) Children observed in the years before introducing UIFSM	BMI, Bodyweight outcomes. *Heights and weight measurement x 1 per school year*	By the end of the school year, on average child who exposed to UIFSM is 1.1 percentage points more likely to be of healthy weight, 0.7 percentage less likely to obese. BMI 4.3% of a standard deviation lower than not exposed child.

Table 4. GRADE assessment of the included studies.

#	Study	Study design	Limitations Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Grade
1.	Gleason et al.	Cohort	No serious limitation (1)	No serious inconsistency	No serious indirectness	No serious imprecision	No	LOW
Risk of bias: Did not have information about what or how much students eat. ***Indirectness:** Included participation to both SBP and NSLP but analyzed relationship to BMI separately.								
2.	Schanzenbach	Cohort panel, cross-sect.	No serious limitation (2)	No serious inconsistency	No serious indirectness	No serious imprecision	Yes	LOW
Risk of bias: Participation for school lunch students report: every day or most days **Publication bias:** Only one author								
3.	Li et al.	Cross-sectional	No serious limitation (3)	No serious inconsistency	No serious indirectness (3*)	No serious imprecision	No	LOW
Risk of bias: Unclear information how they measure school lunch participation. ***Indirectness:** Intervention included also SBP participation								
4.	Baxter, Hardin et al.	Cohort	No serious limitation (4)	No serious inconsistency	No serious indirectness (4*)	No serious imprecision (4*)	No	LOW
Risk of bias/Indirectness: 95 % were black. *SBP were also included as an intervention. ***Imprecision:** Included only 4th grade students.								
5.	Millimet et al.	Cohort panel st. longitudinal	No serious limitation (5)	No serious inconsistency	No serious indirectness	No serious imprecision (5*)	No	LOW
Risk of bias: No direct observation about school meals participations, who consumed and how much. ***Imprecision:** Uncertainty about size of effect. 116 those who participate on SBP and 6,994 those who participate only NSLP.								

6.	Hernandez et al.	Cohort longitudinal	No serious limitation (6)	No serious inconsistency	No serious indirectness (6*)	No serious imprecision (6*)	No	LOW
Risk of bias: Unclear information about participation status, lack of dietary intake. * **Indirectness:** Patterns of NSLP participation. ***Imprecision:** few participant- total n. 1140, never participation n. 211.								
7.	Paxton, Baxter et al.	Cohort	No serious limitation (7)	No serious inconsistency	No serious indirectness (7*)	No serious imprecision	N0	LOW
Risk of bias: Sample was collected in one district**. *Indirectness:** Subset 324 children. Only 4th grade students. SBP participation is included for intervention. Although results are combined with participation on NSLP or measured as individual variable.								
8.	Guinn et al.	Cohort long. Cross-sec.	No serious limitation	No serious inconsistency	No serious indirectness (8*)	No serious imprecision (8*)	No	LOW
*Indirectness: Do not directly meet PICO of this master thesis SR. ***Imprecision:** Homogenous participation sample. Study included only 4th grade students, 95% were black.								
9.	Baxter, Paxton-Aiken et al.	Cohort.	No serious limitation	No serious inconsistency	No serious indirectness (9*)	No serious imprecision	No	VERY LOW
***Indirectness:** Results included both breakfast and lunch participation * Included only 4th grade students.								
10.	Mirtcheva et al.	Cohort long.	No serious limitation (10)	No serious inconsistency	No serious indirectness (10*)	No serious imprecision	No	LOW
Risk of bias: Did not have data of exact number of eating school meals per week. Did not have data of dietary intake and consumption patterns during school day or outside the school. Code usually eats school lunch was 3 times a week in year								

2003 and further, but year 1997 usually ate a complete hot lunch offered at school. ***Indirectness:** differences in interventions in 1997 and 2007. Directly relevant study.								
11.	Capogrossi et al.	Cohort long.	No serious limitation (11)	No serious inconsistency	No serious indirectness (11*)	No serious imprecision	No	LOW
Risk of bias: Participation status were given from parent and school administrator surveys. ***Indirectness:** Directly relevant intervention. Included participation in SBP, but impact on participation in only NSLP were examined as individual variable.								
12.	Vericker et al.	Quasi-experimental intervent	No serious limitation (12)	No serious inconsistency (12*)	No serious indirectness (12*)	No serious imprecision	No	LOW
Risk of bias: Study did not have information about diet quality or food consumption. Follow-up time only 1 year after updated nutrition standards. *Inconsistency of results: Low R2 in several results. ***Directness:** Directly relevant interventions.								
13.	Kenney et al.	Cohort	Few serious limitation (13)	No serious inconsistency (13*)	No serious indirectness (13*)	No serious imprecision	No	VERY LOW
Risk of bias: Parental report of weigh status. Did dot have information how recently policies were implemented. Did not included information about own consumption od school meals and snacks. Who was or was not consuming school meals. ***Inconsistency**: Due the high risk of bias results may not be consistent**. *Indirectness:** Study did include NSLP, SBP and smart snack programs. Results are combined.								
14.	Bardin et al.	Cohort	No serious limitation (14)	No serious inconsistency	No serious indirectness (14*)	No serious imprecision (14*)	No	LOW
Risk of bias: Unclear, exact information about number of participations in school meals. ***Directness:** Study included as an intervention NSLP and SBP but examined result of NSLP as individual variable. ***Imprecision**: Uncertainty about the size of effect.								

15.	Schwartz et al.	Cohort long.	No serious limitation	No serious inconsistency	No serious indirectness (15*)	No serious imprecision (15*)	No	LOW
Risk of bias: ***Directness:** Because of aim of this master thesis, I was primary interested of results that showed impacts of school lunch on weight outcomes. UFM including both free breakfast and lunch, but study analyzed also impact of school lunch as individual variable on weight. ***Imprecision**: Only one of the five weigh indicators results were statistically significant.								
16.	Holford et al.	Cohort	No serious limitation	No serious inconsistency	No serious indirectness (16*)	No serious imprecision	No	LOW
***Directness:** Directly relevant study.								

4 Summary of the main results

A clear message according to the results of the included studies on this SR is that school provided meals alone do not associate with BMI changes among school aged children. Several other factors, such as ethnicity, gender differences, SES, and other family characteristics influenced the results between school provided meals and BMI.

Overall, universal healthy school meals contribute to reducing social and health inequalities and might be beneficial to school performance. However, other variables such as social class, gender, ethnicity and geographical location are related to the patterns of health and illness and influence BMI changes among children (52). Children are more likely to be obese and have higher bodyweight if they are income-eligible for reduced price school lunches. In contrast, children from the higher income families had a lower BMI than those from lower income background. Children who consumed meals at home were more likely to have higher educated parents and higher SES compared to the children who are participating in the school lunch programs (46, 47).

Ethnicity and SES showed to be one of the greatest influencing factors explaining the association between school meals and BMI in the U.S. Eligibility of children for free or reduced-price school meals in the U.S. is linked to a lower SES, with families with an income level at or below 185% of poverty line being qualified for the program (36). Non-white, African American, and Hispanic children are more likely to come from a family with a lower income and participate in school provided meal programs in the U.S. One of the studies shows that 79% of the children who participated in the NSLP were non-Hispanic black, compared to non-Hispanic white children whose participation rate was 33% (34). In addition, non-Hispanic black girls had a higher percentage of being overweight and obese that non-Hispanic black boys (41, 46, 48).

The difference between school-provided meals and home-packed lunch can partly be explained with home resources as mentioned earlier. Families in the lower SES are more likely to be unemployed or/and have lower education. These parents or caregivers more often have less resources to follow-up their children and children may have a lack of support with healthy lifestyle choices. Poor living conditions have been

associated with fewer opportunities for physical activity and greater number of fast-food restaurants in the living area, which as well contribute to obesity. It is known that children living in poverty are exposed to stress. Stressful environment is associated with early puberty, that has been observed as early as at the age of eight among girls. Girls tend to store more body fat, which could explain the results to weight gain among girls in these studies. Parent´s lifestyles, physical activities level and eating behaviors are great predictors that impact to children´s BMI (41).

5 Discussion

Several important points did arise from this thesis. Eligibility for participation in the free NSLP and SBP programs are related to lower income status in the U.S. The results showed that these children are most vulnerable for weight gain and more likely to be obese. Notable is also that in the U.S. low-income children are mainly non-white, African American, and Hispanic children. Households with low SES are often related to employment status and parental educational level. Household with lower SES reflects poorer free time activities, and less opportunities to participate organized activities. Parent's higher education level and employment are associated with reduction in BMI (53) The Nordic countries are known as social democratic welfare states and to have less income inequalities. Remarkable is that social inequalities have been identified to be increasing in the Nordic countries. Also, poverty among children and adolescent has developed in the Nordic countries during the recent years. In Norway the number of children living in low-income households increased from 7.6% in 2006 to 9.4% in 2014. Also, children with immigrant background are increasingly represented in the low-income group (54). This increase has been seen as a public health problem.

The included studies were conducted in the U.S. and one in the UK, where the income structures are different compared to for example the Nordic countries, where the intergenerational income mobility is higher (55). The cost of healthier food is higher than the unhealthy which can explain the higher obesity prevalence in several countries. Also, food cultures and practices vary among countries, and even between municipalities within countries (56, 57).

Approxiamately 30% of daily energy intake of children are consumed at schools (58). WHO and countries separately have created recommendations and nutritional guidelines for intake of sugar, salt, and saturated fat. However, there is a lack of follow up on how the guidelines are applied in school meals. Results from the U.S. school meals are not directly comparable or adoptable to Norway or other Europian countries, as there are differences in diet quality, behaviors and local availability of groceries. Norwegian lunch culture concerning home-packed school lunches include bread, often complemented with vegetables and fruits. There are nutritional guidelines, but no

national policies for home-packed lunches. In contrast, Finland and Sweden provide healthy hot meals at school which are regulated by Ministry of Education (58). These meals also include vegetables and fruits and follow the nutritional guidelines and advice.

Although some of the results showed a positive relationship between school provided meals and weight gain, they also showed how healthy diet can affect children´s overall health. Importantly, healthier diet at school may lead to healthier food choices later in life (5). The studies included in this SR did not describe clearly or exact how many times children participated in school meals per week, and what they ate. Despite these limitations, the results of the included studies support that school provided meals can be beneficial if they meet nutritional recommendations. Regarding the dietary content, previous studies have shown that participation in the NSLP leads to increased intake of fat, but also to lower intake of carbohydrates and added sugars (41). Simultaneously, participation in the NSLP leads to a higher daily intake of several key vitamins and minerals (41). The children attending school provided meals have more nutritional rich lunch content than those with home packed lunch (11).

5.1 Regular meal patterns are beneficial for the health

Related to observations from the included studies, breakfast and regularly meal patterns are important factors for health and wellbeing. Based on the evidence of studies, many children participate in school activities without eating, skip the lunch or have a long time between meals during the day (59). A study by Ober et al. (53) showed that children who ate breakfast on school days had on average lower BMI-SDS and were significantly less likely to be overweight than children who did not eat breakfast. Children who regularly skipped breakfast on school days showed higher risk for being overweight compared to children who skipped breakfast occasionally. Children who skipped the breakfast, also did not eat lunch often. Skipping breakfast or not eating school lunch were positively associated with prevalence of being overweight (53). Skipping the main meals lead easily to higher intake of unhealthy snack food or unhealthy eating behaviors. Several studies have found association between regular main meal consumption and lower BMI (60). In contrast, the study by Vik et al. found that serving free healthy school meals for one year was not associated with lower intake of unhealthy snacks (61).

Schools are perfect arenas for promoting healthy choices and diet behaviors. Studies of school-based interventions that included both a healthier diet and increase in physical activity not only reduced bodyweight but also improved school performance (62, 63). This kind of obesity prevention interventions are improving health and academic performance and could be especially beneficial in areas with vulnerable children with low-income backgrounds.

One of the studies by Bardin et al. (28) did not found association between school provided meals and BMI after legislation. While study by Vericker et al. (37) found evidence for lower BMI among boys but not for girls. Strongest evidence was found by Kenney et al. (51) whose results show that the new nutritional standards reduce obesity among children in poverty. Only two of the included studies showed negative association between school provided meals and BMI. One was conducted recently in the UK and the other one in the U.S., including all the public elementary schools in New York.

According to the previous studies, there is no clear evidence of the effect between free- or reduced-price school lunch and bodyweight changes. Overall the results are showing that healthier diet behavior is beneficial for children from low-income households (28, 64). Results of this thesis are supported by previously published systematic review and few other studies that have been investigating free school lunch programs and overall dietary (5, 36, 59).

5.2 Study implications and future recommendations

The purpose of this thesis is to use the results as evidence and information for the local decision-makers and leaders. Another intention is to rise knowledge and understanding of the importance of healthy school meals and their impact on children´s wellbeing and academic performance.

Universal school meals are reducing social and health inequalities. OWOB is not alone the individuals' responsibility, but an issue where societies at large should take a stand and support the healthy lifestyle changes. The results of this this thesis show how school meals and other societal and lifestyle factors affect bodyweigh changes in school aged children. Policymakers should consider a new point of view in this issue, and develop national and local nutritional guidelines for school provided meals and home-packed lunch.

A notable point identified when working with this thesis was the high OWOB prevalence among Finnish children and adolescent compared to Norway or Sweden despite of the free school meals served both in Finland and Sweden. When comparing the latest data of children with obesity in the UK, U.S and children from the Scandinavian countries Finland, Sweden, and Norway, the U.S and UK score the highest obesity rates.

In the UK 32% of boys and 27.9% of girls were obese and in the U.S 34.5% of boys and 38% of girls. In Scandinavia, Finland has the highest rates of child obesity with 31.3% for boys and 29.8% for girls. Sweden has child obesity rates of 22.6% for boys and 21.2% for girls, and Norway the lowest obesity rates of 15.5% and 16.1% respectively (20). All the three Nordic countries are geographically and societally similar welfare states. It would be interesting to know why there are such differences in obesity rates between Finland and Norway, and if the school provided meals in Finland are associated with the high child obesity rate in the country. Universal school meals are beneficial for health and academic performance, and even though the evidence regarding school provided meals and association to BMI changes is inconclusive, future studies could concentrate on evaluating other factors and school-based interventions that could prevent childhood obesity and overweight.

5.3 Ethical aspects

There are no concerns regarding ethical aspects in this systematic review, as the studies included in the study have been conducted and published earlier.

5.4 Strengths and weaknesses of this review

Strengths of this SR are that it follows strictly the PRISMA protocol for systematic reviews and that the inclusion and exclusion criteria are clearly defined and applied. All the included studies reported BMI as an outcome measurement. Studies in other languages that English were also included in the search criteria, but unfortunately not found.

Studies included in this SR had a similar variation in the participants´ age range. A wide age range gives a broader picture of the overall BMI status though the elementary school, although there are other factors also that might affect the BMI.

Two of the included studies examined other factors that explain BMI changes among fourth-grade children. These studies did not answer direct to the research question of this thesis, but these studies were included to explain more in detail which factors might influence the association between school lunch and BMI changes.

This SR also has some limitations related to the quality of the evidence. Some of the included studies in this SR had several risks of bias and limitations that might affect the reliability of the results. There was heterogeneity in the study population's age range, unclearly defined participation status in school provided lunch, unclearly described school meals and the follow up times had variations. These factors weaken the possibility to detect the impact between school provided meals and BMI.

Second limitation of this SR was that all included studies, except one, were conducted in the U.S. When studies are largely limited to U.S. which restricts the generalizability of the results.

6 Conclusions

School provided meals do not alone associate to BMI changes among school-aged children but can contribute to overall health and academic performance. Schools are important places to reduce social and health inequalities among children. Children are our future, and when investing in them now, there will be lower societal health costs in the future. Early life exposures influence child´s long-term health including eating and dietary habits.

Works cited

1. Hansen LB MJ, Johansen AM.W, Paulsen MM, Andersen LF. . UNG KOST 3 - Landsomfattande kostholdsundersøkelse blant elever i 4.- og 8. klasse i Norge. . Oslo: Universitet i Oslo, Mattilsynet, Helsedirektoratet and FHI; 2015.
2. Vik FN, Van Lippevelde W, Overby NC. Free school meals as an approach to reduce health inequalities among 10-12-year-old Norwegian children. BMC Public Health. 2019;19(1):951-.
3. Torheim LE LA, Huseby CS, Terragni L, Henjum S, Roos G. . Sunnare matomgivelser i Norge. Vurdering av gjeldende politikk og anbefalinger for videre innsats. . Oslo: OsloMet - storbyuniversitet. ; 2020.
4. Kolve CS HA, Bere E. . Gratus skolemat i ungdomsskolen - nasjonal kartlegging av skolematordninger og utprøving av enkel model med et varmt måltid. . Oslo: Folkehelseinstituttet; 2022.
5. Colombo PE, Patterson E, Elinder LS, Lindroos AK. The importance of school lunches to the overall dietary intake of children in Sweden: a nationally representative study. Public Health Nutr. 2020;23(10):1705-15.
6. Juniusdottir R, Hörnell A, Gunnarsdottir I, Lagstrom H, Waling M, Olsson C, et al. Composition of School Meals in Sweden, Finland, and Iceland: Official Guidelines and Comparison With Practice and Availability. J Sch Health. 2018;88(10):744-53.
7. Panter J, Tanggaard Andersen P, Aro AR, Samara A. Obesity Prevention: A Systematic Review of Setting-Based Interventions from Nordic Countries and the Netherlands. J Obes. 2018;2018:7093260-34.
8. Berggren L, Talvia S, Fossgard E, Björk Arnfjörð U, Hörnell A, Ólafsdóttir AS, et al. Nordic children's conceptualizations of healthy eating in relation to school lunch. Health education (Bradford, West Yorkshire, England). 2017;117(2):130-47.
9. Wethington HR, Finnie RKC, Buchanan LR, Okasako-Schmucker DL, Mercer SL, Merlo C, et al. Healthier Food and Beverage Interventions in Schools: Four Community Guide Systematic Reviews. American journal of preventive medicine. 2020;59(1):e15-e26.
10. USDA USDoA. Child Nutrition Programs [updated November 10, 2021.
11. Angus Holford BR. Going universal. The impact of free school lunches on child body weight outcomes. . Journal of Public Economics Plus (2022). 2020.
12. Asakura K, Sasaki S. School lunches in Japan: their contribution to healthier nutrient intake among elementary-school and junior high-school children. Public Health Nutr. 2017;20(9):1523-33.
13. OurWorldindata. Share of children that are overweight [cited 2021 September 1 th]. Available from: https://ourworldindata.org/obesity#what-share-of-adults-are-overweight.
14. de Laat S, de Vos I, Jacobs M, van Mil E, van de Goor I. The evaluation of an integrated network approach of preventive care for children with overweight and obesity; Study protocol for an implementation and effectiveness study. BMC Public Health. 2019;19(1):979-.
15. WHO. Obesity and overweight 2022 [updated 9 of June 2021. Obesity and overweight]. Available from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.
16. Lokling HL, Roelants M, Kommedal KG, Skjakodegard H, Apalset EM, Benestad B, et al. Monitoring children and adolescents with severe obesity: body mass index (BMI), BMI z-score or percentage above the International Obesity Task Force overweight cut-off? Acta Paediatr. 2019;108(12):2261-6.
17. Danielsen YS. Fedme hos barn. Intervensjoner og atferdsendringer i praksis. Oslo: Kommuneforlaget AS; 2014. 145 p.

18. Mead E, Brown T, Rees K, Azevedo LB, Whittaker V, Jones D, et al. Diet, physical activity and behavioural interventions for the treatment of overweight or obese children from the age of 6 to 11 years. Cochrane Database Syst Rev. 2017;2017(6):CD012651-CD.
19. NorwegianDirectorateofHealth. [cited 2021 semtember 5th]. Available from: https://www.helsedirektoratet.no.
20. WorldObesity. Global obesity observartory [cited 2021 September 5 th]. Available from: . https://data.worldobesity.org.
21. Elvsaas IKØ, Giske L, Fure B, Juvet LK. Multicomponent Lifestyle Interventions for Treating Overweight and Obesity in Children and Adolescents: A Systematic Review and Meta-Analyses. J Obes. 2017;2017:5021902-14.
22. de Wit JBF, Stok FM, Smolenski DJ, de Ridder DDT, de Vet E, Gaspar T, et al. Food Culture in the Home Environment: Family Meal Practices and Values Can Support Healthy Eating and Self-Regulation in Young People in Four European Countries. Applied Psychology: Health and Well-Being. 2015;7(1):22-40.
23. Brown T, Moore THM, Hooper L, Gao Y, Zayegh A, Ijaz S, et al. Interventions for preventing obesity in children. Cochrane Database Syst Rev. 2019;2019(7):CD001871-CD.
24. Wang Y, Cai L, Wu Y, Wilson RF, Weston C, Fawole O, et al. What childhood obesity prevention programmes work? A systematic review and meta-analysis. Obes Rev. 2015;16(7):547-65.
25. **Elinder LS PE, Nyberg G, Norman Å**. A Healthy School Start Plus for prevention of childhood overweight and obesity in disadvantaged areas through parental support in the school setting - study protocol for a parallel group cluster randomised trial. BMC. 2018.
26. SchoolNutritionAssociation. Nutrition Standards for School Meals [cited 2022 8th of March]. Available from: https://schoolnutrition.org/uploadedFiles/About_School_Meals/What_We_Do/Nutrition-Standards-for-School-Meals.pdf
27. Taber DR, Chriqui JF, Powell L, Chaloupka FJ. Association Between State Laws Governing School Meal Nutrition Content and Student Weight Status: Implications for New USDA School Meal Standards. JAMA Pediatr. 2013;167(6):1-8.
28. Bardin S, Gola AA. Analyzing the Association between Student Weight Status and School Meal Participation: Evidence from the School Nutrition and Meal Cost Study. Nutrients. 2020;13(1).
29. Sabinsky MS, Toft U, Sommer HM, Tetens I. Effect of implementing school meals compared with packed lunches on quality of dietary intake among children aged 7-13 years. J Nutr Sci. 2019;8:e3.
30. Farris ARMSRD, Misyak SP, Duffey KJP, Davis GCP, Hosig KPRD, Atzaba-Poria NP, et al. Nutritional Comparison of Packed and School Lunches in Pre-Kindergarten and Kindergarten Children Following the Implementation of the 2012–2013 National School Lunch Program Standards. J Nutr Educ Behav. 2014;46(6):621-6.
31. PRISMA. Transparent reporting of systematic reviews and meta-analyses [cited 2022.
32. Vik LC, Lannem AM, Rak BM, Stensrud T. Health status of regularly physically active persons with spinal cord injury. Spinal Cord Ser Cases. 2017;3:17099.
33. JBI MfES. JBI 2020 [Available from: https://synthesismanual.jbi.global.
34. Hernandez DCF, Lori A.; Doyle, Emily A. National School Lunch Program Participation and Gender Differences in Low-income Children's BMI Trajectories. National institutes of health 2013:16.
35. Capogrossi K, You W. The Influence of School Nutrition Programs on the Weight of Low-Income Children: A Treatment Effect Analysis. Health Econ. 2017;26(8):980-1000.
36. Cohen JFW, Hecht AA, McLoughlin GM, Turner L, Schwartz MB. Universal School Meals and Associations with Student Participation, Attendance, Academic Performance, Diet

Quality, Food Security, and Body Mass Index: A Systematic Review. Nutrients. 2021;13(3):911.
37. Vericker TC, Gearing ME, Kim SD. Updated Nutrition Standards for School Meals Associated With Improved Weight Outcomes for Boys in Elementary School. Kent, OH :2019. p. 907-15.
38. Institute of Education Sciences USDoE. Early Childhood Longitudinal Studies (ECLS) Program USA: IES & NCES; [cited 2022 3th Mai].
39. Health DRCfCA. The National Suvey of Children´s Health [
40. center. IfsrSr. Panel study of income dynamics. [Available from: https://psidonline.isr.umich.edu/Guide/Brochures/CDS.pdf.
41. Gleason PMP, Dodd AHP. School Breakfast Program but Not School Lunch Program Participation Is Associated with Lower Body Mass Index. J Am Diet Assoc. 2009;109(2):S118-S28.
42. Schwartz AE, Rothbart MW. Let Them Eat Lunch: The Impact of Universal Free Meals on Student Performance. Journal of policy analysis and management. 2020;39(2):376-410.
43. Baxter SD, Hardin JW, Guinn CH, Royer JA, Mackelprang AJ, Devlin CM. Children's body mass index, participation in school meals, and observed energy intake at school meals. Int J Behav Nutr Phys Act. 2010;7(1):24-.
44. Paxton AEMPHRDLD, Baxter SDPRDLDF, Tebbs JMP, Royer JAM, Guinn CHRDLD, Devlin CMRDLD, et al. Nonsignificant Relationship between Participation in School-Provided Meals and Body Mass Index during the Fourth-Grade School Year. J Acad Nutr Diet. 2012;112(1):104-9.
45. Mirtcheva DM, Powell LM. National School Lunch Program participation and child body weight. Eastern economic journal. 2013;39(3):328-45.
46. Schanzenbach DW. Do School Lunches Contribute to Childhood Obesity? The Journal of human resources. 2009;44(3):684-709.
47. Millimet DL, Tchernis R, Husain M. School Nutrition Programs and the Incidence of Childhood Obesity. The Journal of human resources. 2010;45(3):640-54.
48. Li J, Hooker NH. Childhood Obesity and Schools: Evidence From the National Survey of Children's Health. J Sch Health. 2010;80(2):96-103.
49. Baxter SD, Paxton-Aiken AE, Tebbs JM, Royer JA, Guinn CH, Finney CJ. Secondary analyses of data from 4 studies with fourth-grade children show that sex, race, amounts eaten of standardized portions, and energy content given in trades explain the positive relationship between body mass index and energy intake at school-provided meals. Nutr Res. 2012;32(9):659-68.
50. Guinn CH, Baxter SD, Royer JA, Hitchcock DB. Explaining the Positive Relationship Between Fourth-Grade Children's Body Mass Index and Energy Intake at School-Provided Meals (Breakfast and Lunch). J School Health. 2013;83(5):328-34.
51. Kenney EL, Barrett JL, Bleich SN, Ward ZJ, Cradock AL, Gortmaker SL. Impact Of The Healthy, Hunger-Free Kids Act On Obesity Trends: Study examines impact of the Healthy, Hunger-Free Kids Act of 2010 on childhood obesity trends. Health Affairs. 2020;39(7):1122-9.
52. Nettleton S. The Sociology of Health and Illness 3rd edition ed. Cambridge UK: Polity Press; 2013. 292
p.
53. Ober P, Sobek C, Stein N, Spielau U, Abel S, Kiess W, et al. And yet Again: Having Breakfast Is Positively Associated with Lower BMI and Healthier General Eating Behavior in Schoolchildren. Nutrients. 2021;13(4):1351.

54. Povlsen L, Regber S, Fosse E, Karlsson LE, Gunnarsdottir H. Economic poverty among children and adolescents in the Nordic countries. Scand J Public Health. 2018;46(20_suppl):30-7.
55. Wiborg ØN, Grätz M. Parents' income and wealth matter more for children with low than high academic performance: Evidence from comparisons between and within families in egalitarian Norway. Research in social stratification and mobility. 2022;79.
56. Wardle J, Haase AM, Steptoe A, Nillapun M, Jonwutiwes K, Bellisle F. Gender differences in food choice: the contribution of health beliefs and dieting. Ann Behav Med. 2004;27(2):107-16.
57. Westenhoefer J, von Katzler R, Jensen H-J, Zyriax B-C, Jagemann B, Harth V, et al. Cultural differences in food and shape related attitudes and eating behavior are associated with differences of Body Mass Index in the same food environment: cross-sectional results from the Seafarer Nutrition Study of Kiribati and European seafarers on merchant ships. BMC Obes. 2018;5(1):1-.
58. Lucas PJ, Patterson E, Sacks G, Billich N, Evans CEL. Preschool and School Meal Policies: An Overview of What We Know about Regulation, Implementation, and Impact on Diet in the UK, Sweden, and Australia. Nutrients. 2017;9(7):736.
59. Kristine E I, Elling B, Nina C Ø, Renate H, Kirsten O P, FrØYdis N VIK. Intervention study on school meal habits in Norwegian 10–12-year-old children. Scand J Public Health. 2017;45(5):485-91.
60. Lehto R, Ray C, Lahti-Koski M, Roos E. Meal pattern and BMI in 9–11-year-old children in Finland. Public Health Nutr. 2011;14(7):1245-50.
61. Vik FN, Heslien KEP, Van Lippevelde W, Overby NC. Effect of a free healthy school meal on fruit, vegetables and unhealthy snacks intake in Norwegian 10- to 12-year-old children. BMC Public Health. 2020;20(1):1369.
62. Hollar D, Messiah SE, Lopez-Mitnik G, Hollar TL, Almon M, Agatston AS. Effect of a Two-Year Obesity Prevention Intervention on Percentile Changes in Body Mass Index and Academic Performance in Low-Income Elementary School Children. Am J Public Health. 2010;100(4):646-53.
63. Bartelink NHM, van Assema P, Kremers SPJ, Savelberg HHCM, Oosterhoff M, Willeboordse M, et al. Can the Healthy Primary School of the Future offer perspective in the ongoing obesity epidemic in young children? A Dutch quasi-experimental study. BMJ Open. 2019;9(10):e030676-e.
64. Vik FN, Van Lippevelde W, Overby NC. Free school meals as an approach to reduce health inequalities among 10-12- year-old Norwegian children. BMC Public Health. 2019;19(1):951.
65. THEWORLDBANK. Data of High income countries 2021 [cited 2021 15th November]. Available from: https://data.worldbank.org/income-level/high-income?view=chart.

Appendix 1

List of high-income countries

Countries and territories that are defined as a high-income country when national income per capita exceeding 12,056 dollar. November 2020, 77 countries and territories were classified as high-income country by World Bank. These were; Andorra, Antigua and Barbuda, Aruba, Australia, Austria, Bahamas, Bahrain, Barbados, Belgium, Bermuda, British Virgin Islands, Brunei Darussalam, Canada, Cayman Islands, Chanel Island, Chile, Croatia, Curacao, Czech Republic, Denmark, Estonia, Faroe Islands, Finland, France, French Polynesia, Germany, Gibraltar, Greece, Greenland, Guam, Hong Kong Sar, China, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea Rep., Kuwait, Latvia, Liechtenstein, Lithuania, Luxembourg, Macao Sar China, Malta, Monaco, Nauru, Netherlands, New Caledonia, New Zealand, Northern Mariana Islands, Norway, Oman, Palau, Poland, Portugal, Puerto Rico, Qatar, San Marino, Saudi Arabia, Seychelles, Singapore, Sint Maarten (Dutch Part), Slovak Republic, Slovenia, Spain, St. Kitts and Nevis, St. Martin (French part), Sweden, Switzerland, Trinidad and Tobago, Turks and Caicos Islands, United Arab Emirates, United Kingdom, United States, Uruguay and Virgin Island (10) (65).

Table 5. Characteristics, results, and GRADE assessment of the included studies.

Table 5. Characteristics, results, and GRADE assessment of the included studies.

Author, year, location, study design	Title	Study aim	Population	Intervention Comparison	Outcome(s)	Results	Grade
1. Gleason et al 2009, USA ***Cohort***	School Breakfast Program but Not School Lunch Program Participation Is Associated with Lower Body Mass Index	To estimate the relationship between participation in school meal programs and BMI and likelihood of being overweight or obese.	Sample of 2,228 1st to 12th grade children. Students from school year 2004-2005.	Participation in NSLP and SBP programs. Nonparticipants	Four outcomes' variables, based on student´s measured BMI. BMI z-scores.	No evidence of relationships between school lunch participation and four BMI-related outcomes. School breakfast participation was associated with significantly lower BMI, declined by 0.15 points ($p<0.05$).	LOW
2. Schan-zenbach 2009, USA ***Cohort panel and Cross-sectional***	Do school lunches contribute to childhood obesity?	Assess whether school lunches contribute to childhood obesity	Children from kindergarten through eighth grades. Data from 15,000 students, 1000 different schools.	3,295 School lunch participation 1,546 Students who consumed brown bag from home their lunch.	BMI, BMI z-scores	Children who consumed school lunches are two percentage points more likely to be obese compared brown bag-consumers. Though they enter kindergarten with the same obesity rates	LOW
3. Ji Li et al. 2010, USA	Childhood obesity and schools: Evidence	Explore the relationships between childhood obesity	Children aged 6 to 17 years.	Participation in NSLP/SBP at public school	BMI	If child attends public school and is eligible for the NSLP/SBP, BMI is 0,725 ($p<.001$) higher than	LOW

***Cross-sectional*.**	from the national survey of children's health	and school type, NSLP and SBP eligibility, membership in sport clubs and other sociodemographic and household factors.	Totally 62,872 observations of	Participation in NSLP/SBP at private school.		children attending private schools. Children eligible for NSLP or SBP have a 4.5% higher probability of being overweight.	
4. Baxter, Hardin et al. 2010, USA ***Cohort***	Children´s BMI, participation in school meals, and observed energy intake at school meals.	Investigate a possible relationship of BMI with daily participation in school meals and observed intake at school meals, and whether the relationships differed by breakfast location.	1,571 fourth-grade children Data collected during three school years: 2004-05, 17 schools 2005-06, 17 schools. 2006-05 8 schools	School lunch and school breakfast participation. Seven of the schools had breakfast in the classroom, all other in the cafeteria. *Observation of school meals intake by research staff.*	BMI	Breakfast, lunch participation and combined participation were not significantly associated with BMI. BMI relationship with sex was significant (P<0.001) average BMI for boys 20.56 girls 21.33 BMI related to age was significant (p=0.006) BMI increased by 0.06kg/m as age increased by on month Breakfast locations was significant (p=0.012) associated with BMI. Average BMI was higher for children with breakfast in the classroom (21.50) than in cafeteria (20.54).	LOW
5. Millimet et al. 2010, USA	School nutrition programs and the incidence of childhood obesity	Assess the relationship between SBP and NSLP participation and (relatively) long-	13,531 children from 994 schools.	3,347 participate both in SBP and NSLP	BMI, change of BMI percentile	Positive association between participation NSLP and child weight gain, 6.8 percent increase in the probability of being obese in third grade.	LOW

Cohort panel study, longitudinal		run measures of child weight.		6,994 participate only NSLP 116 participate only SBP. 3,074 non-participating in NSLP or SBP			
6. Hernandez et al. 2013, USA ***Cohort Longitudinal, secondary data analysis***	National School Lunch Program Participation and Gender Differences in Low-income Children´s BMI Trajectories	To investigate participation patterns in the NSLP among low-income children. Examine the ways in which participation influences gender differences in BMI trajectories through the eighth grade.	Kindergarten to eight grades, low-income students totally 1,140 girls n.574, boys n.566	Participation in the NSLP Non-participating in the NSLP	Patterns of NSLP participation. Age- and sex-specific BMI	82% participated in NSLP. 35% persistent, 47% transient. No significant change in average levels of BMI. Results suggest participation in NSLP is associated with rapid weight gain for low-income girls, but not for boys compared to non-participating.	LOW
7. Paxton, Baxter et al. 2012, USA ***Cohort***	Non-significant relationship between participation in school-provided meals and Body Mass Index during the fourth-grade school year.	This secondary analysis investigates 1. a possible relationship between school-meal participation and childhood obesity. 2. For a subset of children, the effect that observed energy intake at school-provided meals	Fourth grade, children 1,535. From 6 to 11 elementary school in Augusta, GA. During 4 school years, years 1999 to 2003.	Participation in school meals SBP and lunch (*Direct meal participation of 342 children. Total 1,264 school meals, 50% breakfast)*	BMI *Weight/height measurements by research staff* *Energy intake at school meals.*	No significantly relationship between school-meal participation and BMI (p> 0.594). Results support a positive relationship between observed energy intake at school meals and BMI increase.	LOW

		has on the relationship between school-meal participation and childhood obesity.					
8. Guinn et al. 2013, USA ***Cohort, longitudinal*** **Cross-sectional study**	Explaining the positive relationship between fourth-grade children´s body mass index and energy intake at school-provided meals (Breakfast and Lunch)	To help explain positive relationship between children´s BMI and energy intake at school provided meals that a 2010 publication showed (Baxter, Hardin et al. nr.4).	Of the fourth grade 1,730 children, 465 was randomly selected for meal observation. Data collected during 2004-2007. 1 school district in Columbia, South Carolina	Participation in SBP and NSLP, observed by research staff.	BMI -Energy content of items selected in kilocalories -Number of meal components selected -Number of meal components eaten -Amounts eaten of standardized school-meal portions -Energy intake from flavored milk -Energy content given in trades -Energy intake received in trades	BMI was positively related to energy intake from flavored milk (p=.0041). *BMI* was positively related to amounts eaten of standardized school-meal portions(p<.0001) BMI was neg. related to energy intake received in trade.	LOW
9. Baxter, Paxton-Aiken et al. 2012, USA ***Cohort***	Secondary analyses of data from 4 studies with fourth-grade children show that sex, race, amounts eaten of standardized portions, and energy content given	To help explain a positive relationship between children´s BMI and energy intake at school-provided meals that a 2012 article showed (Paxton AE., Baxter et al. nr.7)	328 fourth-grade children, randomly selected for meal obeservation From total 13 schools, 6 to 11 public elementary schools per	Participation in school-provided meals, breakfast, and lunch, total *1178* school meals observed.	BMI Six daily energy intake aspects of school meals; -Amounts eaten of standardized portions -Energy content given in food trades	Daily energy intake at school-provided meals was significantly (P< .0001) related to BMI, the average BMI 0.52 kg/m increased for each 100-kcal increase in intake at school meals. Amounts eaten was significantly (P <.0001) related to BMI. BMI increased 2.98 kg/m on average per 100-kcal increase.	VERY LOW

	in trades explain the positive relationship between body mass index and energy intake at school-provided meals.	Purpose of this study was to investigate 1. whether the relationship differed by sex and race. 2. the relationship between BMI and six aspects of school-provided meals.	school year. 1 district in Augusta, Georgia.		-Energy intake received in food trades -Energy intake from flavored milk -Energy intake from a la carte ice cream, -Breakfast type.	Energy content given in food trades was (P=.0052) negatively related to BMI. BMI decreased 1.04 kg/m on average for every 100-kcal given. Sex was significantly (P=.0040) related to BMI, average greater for female. Race was significantly (P=.0002) related to BMI, BMI estimated to be greater for black children 1.62 kg/m. Age and study were not significantly related to BMI.	
10. Mirtcheva et al. 2013, USA ***Cohort Longitudinal study design.***	National School Lunch Program Participation and Child Body Weight	Examines the relationship between NSLP participation and body weight.	Totally 3,204 children, aged 6 to 18, attending to public schools. Data from 1997 to 2003.	Participation in NSLP *Sample of 1,576 observations.*	BMI percentile and body weight classification, overweight/obese and obese status.	Basis of the individual-level fixed effects (FE) results this study does not find evidence that school lunches are related to higher weight outcomes.	LOW
11. Capogrossi et al. 2017, USA	The influence of school nutrition programs on the weight of low-income children: A	This study examines children´s weight progress from 1st to 8th grade, while recognizing the potential effects	Totally 14,710 students included, from 1st through 8th grade. Low-income children	Participation in both NSLP and SBP	Weight, BMI z-scores	Results of DID show that short-term participation (participating NSLP in 5th grade) in only NSLP increases probability to be overweight 0.059 (P=0.03). Participating both program in 8th grade have statically significant	LOW

Cohort, longitudinal (DID) (ATT)	treatment effect analysis	on those children participating in both programs compared with those children participating in only one program.	eligible for free school meals.	Participation in only one program *School meals participation status were asked from parents*		increased 0.086 (P=0.04) probability of being overweight and a decreased -0.071 (P=0.04) probability of being healthy weight. Statistically significant results of ATT show that participation in both program from 1st grade through 8th grade increases the 0.231 probability of being overweight. Participating in only NSLP comparing both programs over the same period having lower (-0.299) probability of being overweight.	
12. Vericker et al. 2019, USA ***Quasi-experi-mental intervention, longitudinal***	Updated nutrition standards for school meals associated with improved weight outcomes for boys in elementary school	Study assesses the association between implementation of the updated nutrition standards and child weight.	Data from year 1999, 9249 children Data from year 2011, 5480 children.	Participation in NSLP n=5480 Nonparticipants in NSLP n= 9240	BMI z-scores *Heigh and weight assessed from the data.* *NSLP participation status were asked from parents.*	After implementation of updated nutrition standards, boys who participated in NSLP experienced slower BMI z-score growth than nonparticipants. No statistically significant relationship between school lunch participation and BMI z-scores for girls after implementation.	LOW
13. Kenney et al. 2020, USA	Impact Of the Healthy, Hunger-Free Kids Act On	Purpose with this study was to estimate whether the HHFKA changes reduced	Children aged 10 to 17 years. Totally 173,013 participants.	Participation in school meals before the implementation	Obesity, having a BMI above the ninety-fifth percentile.	No significant evidence for a change in the risk of having obesity after implementation (OR:0.98; p> 0.05)	VERY LOW

Cohort	Obesity Trends.	the public health burden of childhood obesity among a nationally representative sample of school-age children.	in all US states and the District of Columbia from 2003 to 2018. Time points before 2003, 2007, 2011- 12 after implementation 2016-2018.	of the HHFKA policies Participation in school meals after the implementation of the HHFKA policies		For children in poverty, HHFK act was associated with significant reduction in the risk of obesity (OR: 0.91 per year; p= 0.004). *No significant association between legislation and childhood obesity trends overall.*	
14. Bardin et al. 2020, USA ***Cohort***	Analyzing the Association between Student Weight status and School meal participation: Evidence from the School Nutrition and Meal Cost Study	This study re-examines the association between students' weight status and participation in the NSLP and SBP after the implementation of the updated meals standard changes to determine whether and how this relationship changed.	Children aged 6 to 19, Totally 2165 students, across, 293 public schools. Years 2014/15 Valid measurements were of 1963 students.	Participating in the NSLP and SBP.	BMI, indicator for overweight and obese. Indicator for obesity.	Participation in the school meal programs has no clear association with student´s weight status	LOW
15. Schwartz et al. 2020, USA ***Cohort,* longitudinal**	Let them eat Lunch: The impact of Universal free meals on student performance	This study investigates the impact of extending of free school lunch to all students, regardless of income on	For all public elementary New York City schools. Elementary and middle school students.	Participation in UFM school lunch	Academic outcomes, school meal participation, BMI z-scores	No evidence of increases in average BMI. Some evidence that school lunch improves weight outcomes for non-poor students. Statistically significant result that 2.5% point	LOW

		academic performance in New York City middle schools.	Total 645,204 students. 2010 to 2013.			decrease in the probability of being obese for non-poor students Other results are insignificant among impact of SLP on weight outcomes. No evidence that UFM increases the probability that students are obese or overweight.	
16. Holford et al. 2022, UK **Cohort**	Going universal – The impact of free school lunches on child body weight outcomes.	This study investigates whether providing free, high-quality lunches to children in school can contribute to reducing childhood obesity.	Total in 16,000, Children aged 4-5 and 10-11. School years from 2008/09 to 2017/18	Participation in universal free school meals (UIFSM)	BMI, Bodyweight outcomes. *Heights and weight measurement x 1 per school year*	By the end of the school year, on average child who exposed to UIFSM is 1.1 percentage points more likely to be of healthy weight, 0.7 percentage less likely to obese. BMI 4.3% of a standard deviation lower than not exposed child.	LOW

List of excluded full-text articles

	Authors, year, location	Title	Reason for excluding
1.	Gleason P. M., Suitor C.W. 2003, USA.	Eating at school: How the National school lunch program affects children´s diet.	Too old.
2.	Hofferth S,L., Curtin S. 2005, USA.	Poverty, Food Programs, and Childhood Obesity.	Too old
3.	Wojcicki J.M., Heyman M.B. 2006. USA	Healthier Choices and Increased participation in a middle school lunch program: Effects of Nutrition Policy Changes in San Francisco,	Did not answer to research question.
4.	Baxter SD, Smith AF, Litaker MS, et al. 2006, USA	Body mass index, sex, interview protocol, and children's accuracy for reporting kilocalories observed eaten at school meals.	Intervention and outcome do not meet the inclusion criteria.
5.	Fox M.K., Dodd A.H, Wilson A., Gleason P.M. 2008, USA	Association between school food environment and practices and body mass index of US public school children	Did not answer the research question.
6.	A.S. Ask, S. Hernes, I.Aarek, F. Vik, C.Brodahl and M. Haugen. 2008, Norway	Serving of free school lunch to secondary-school pupils – a pilot study with health implications	Follow up time too short, just 4 months.
7.	Prynne C.J., Handford C., Dunn V. et al. 2010, UK.	The quality of midday meals eaten at school by adolescents; school lunches compared with packed lunches and their contribution to total energy and nutrient intake.	Did not answer the research question.
8.	Anderson P.M., Butcher K.F., Casio E.U., Schanzenbach D.W. 2011, USA.	Is being in school better? The impact of school on children´s BMI when starting age is endogenous.	Did not answer the research question.
9.	Stevens L., Jo N., Wood L., Nelson M. 2013, UK	School lunches v. packed lunches: a comparison of secondary schools in England following the introduction of compulsory school food standards.	Did not answer the research question.
10.	Anderson R., Biltoft-Jensen A., Christensen T. et al. 2013, Denmark	Dietary effects of introducing school meals based on the New Nordic Diet – randomized controlled trial in Danisc children. The OPUS school meal study.	Did not answer the research question.
11.	A. J Williams, W. E Henley, C. A Williams, A.J Hurst,	Systematic review and meta-analysis of the association between childhood overweight and obesity and primary	Not relevant study design

	S. Logan, K. M Wyatt. 2013, UK.	school diet and physical activity policies.	
12.	Cardel M., Willig A.L., et al. 2014, USA	Home-schooled children are thinner, leaner, and report better diets to traditionally schooled children.	Did not answer the research question.
13.	Greece J.A., Kratze A., DeJong W. et al. 2015, USA	Body Mass Index and Sociodemographic Predictors of School Lunch Purchase Behavior during a Year-Long Environmental Intervention in Middle School	Did not answer the research question. – exactly – read
14.	Asakura K., Sasaki S. 2016, Japan.	School lunches in Japan: their contribution to healthier nutrient intake among elementary-school and junior high-school children.	Did not answer the research question.
15.	Willeboordse M., Jansen M.W., van den Heijkant S.N. et al. 2016, Netherlands.	The Healthy Primary School of the Future: study protocol of a quasi-experimental study.	Did not answer the research question.
16.	Sabinsky M.S.,Toft U., Sommer H.M., Tetens I. 2019, Denmark.	Effect of implementing school meals compared with packed lunches on quality of dietary intake among children aged 7-13 years.	Did not answer the research question. BMI outcomes missing.
17.	Vik F.N., Næss I.K., Heslien K. E. P., Øvergy N. C. 2019, Norway.	Possible effect of a free, healthy school meal on overall meal frequency among 10-12-year-olds in Norway: the school meal project.	Did not answer the research question.
18.	Barteling N. H. M., van Assema P., Kremers S. P. J. et al. 2019, Netherland.	Can the Healthy Primary School of the Future offer perspective in the ongoing obesity epidemic in young children? A Dutch quasi-experimental study.	Did not answer the research question.
19.	Colombo P.E., Patterson E., Elnder L.S., Lindroos A.K. 2020, Sweden.	The importance of school lunches to the overall dietary intake of children in Sweden: a nationally representative study.	Did have BMI as an outcome.
20.	Vik F. N. Heslien K. E. P., Van Lippevelde W., Øverby N.C. 2020, Norway	Effect of a free healthy school meal on fruit, vegetables, and unhealthy snack intake in Norwegian 10- to 12-year-old children.	Did not answer the research question. – no result of BMI - school meal
21.	Spence S., Matthews J. NS., McSweewey L. et al. 2020, UK.	Implementation of Universal Infant Free School Meals: a pilot study in NE England exploring the impact on Key Stage 1 pupil´s dietary intake.	Did not answer the research question.
22.	Lundbord P., Rooth D-O., Alex-Petersen J. 2021, Sweden.	Long-Term Effects of Childhood nutrition: Evidence from a School Lunch Reform.	Did not answer the research

			question. Used old data.
23.	P. Ober, C. Sobek, N. Stein, U. Spielau, S.Abel, W. et al. 2021, Germany	And yet Again: Having breakfast Is Positively Associated with Lower BMI and Healthier General Eating Behavior in Schoolchildren.	Did not included school lunch, only breakfast.
24.	J. F. W Cohen, A.A Hecht, G. M. McLoughlin, L. Turner, M. B. Schwartz. 2020, USA .	Universal School Meals (UFSM) and Associations with Student Participation, Attendance, Academic Performance, Diet Quality, Food Security and BMI: A systematic Review	Not relevant study design