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Impact of Implementing Free School Meals on Dietary Habits Among Upper Secondary School Students in Viken County

Betydningen av å innføre et gratis skolemåltid på kostholdsvaner blant elever i Viken videregående skole.

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Acknowledgments

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Sammendrag

Bakgrunn: Hva man spiser har stor betydning for helsen. Andelen sykdommer og dødsfall som kan tilskrives kosthold er stigende. 94 millioner dødsfall var i 2019 tilskrevet kosthold alene. Å ha et sunt og næringsrikt kosthold er derfor viktig, spesielt i oppveksten hvor matvaner formes. Barn og unge bruker store delen av sin oppvekst på skolen og det argumenteres derfor med at skolemat kan bidra til å forme hensiktsmessige kostvaner. I skoleåret 2021-2022 ble det gjennomført et pilotprosjekt i Viken fylke hvor et gratis skolemåltid ble prøvd ut på 12 videregående skoler. Tall fra Skolematundersøkelsen av FHI ble benyttet til å undersøke endringer i elevenes kosthold etter ett år med tiltaket.

Hensikt: Hensikten med denne oppgaven var å undersøke om et gratis skolemåltid hadde en betydning for kostvaner i skoletiden blant ungdom i videregående skoler i Viken fylke. Frokost og lunsjvaner, samt inntak av frukt, grønt, snacks og forskjellige typer drikke ble undersøkt.

Metode: Data fra Skolematundersøkelsen 2021 og 2022 ble benyttet. Tre skoler som deltok i pilotprosjektet, ble inkludert i studien og fikk status som intervensjon. Det ble valgt ut tre kontrollskoler uten skolemattilbud for å sammenligne en eventuell endring i kostholdsvaner i populasjonen. Utvalget ved baseline besto av 1671 respondenter, fordelt på 837 svar ved intervensjonsskolene og 834 svar fra elever på kontrollskolene. Datamaterialet ved oppfølging besto av 707 svar fra intervensjonsgruppen og 1273 svar fra kontrollgruppen (total n=1980). Krysstabulering og mulitlevel mixed model ble benyttet for å analysere endring i spisevaner. Utfallsvariablene var frokost og lunsjfrekvens, samt frukt, grønt, snacks og drikke.

Resultater: Det ble ikke observert noen signifikante forskjeller i kostholdet fra 2021 til 2022 mellom intervensjon og kontrollgruppen. Resultatene i regresjonsmodellen viste en liten, men positiv endring i frokostfrekvens i 2022, blant intervensjonsgruppen og i interaksjonen tid x skolestatus, som indikerer at skolemåltidet hadde en positiv påvirkning blant studenter i intervensjonsgruppen og at det også var en forskjell i oppfølgingsstudien. Å droppe frokost var assosiert med lav SES og det var noe høyere frekvens blant jenter i begge grupper. For lunsjfrekvens og kostskår ble det ikke observert noen signifikante funn.

Konklusjon: Innføring av gratis skolemat viste ingen signifikant forbedring i studentenes kostholdsvaner. Derimot er et mange faktorer og forhold ved metoden og gjennomføring pilotprosjektet som kan ha bidratt til disse funnene. Det bør derfor gjøres flere studier som undersøker denne problemstillingen.

Nøkkelord: Skolemat, kostvaner, ungdom, folkehelse

Summary

Background:

Objective: The objective of this study was to investigate whether a free school meal had an impact on eating habits during school time among adolescents at upper secondary schools in Viken county. Breakfast and lunch habits, as well as consumption of fruit, vegetables, snacks, and various types of beverages, were examined.

Method: Data from *The School Meal Survey* conducted in 2021 and 2022 were used for analysis. The study included three schools that participated in the pilot project and were classified as intervention schools. Three control schools without school meals were selected to compare a possible change in dietary habits in the population. The sample at baseline consisted of 1,671 respondents. 837 were responses from the intervention schools, and 834 responses from students at the control schools. At follow-up, the sample consisted of 707 responses from the intervention group and 1273 responses from the control group (total n=1980). Cross-tabulation and a multilevel mixed model were used to analyze changes in eating habits. The outcome variables were breakfast and lunch frequency and fruit, vegetables, snacks, and beverages.

Results: No significant differences in eating habits were observed from 2021 to 2022 between the intervention and the control group. The fixed effects in the multilevel mixed model showed a small but positive change in breakfast frequency in the follow-up, among the intervention group, and in the time x school status interaction, indicating that school meals had a positive impact on students in the intervention schools and that the difference occurred at follow-up. Skipping breakfast was associated with lower SES and was more frequent among girls in both groups. No significant findings were observed for lunch frequency and diet scores.

Conclusion: The introduction of free school meals showed no significant improvement in the students' dietary habits. On the other hand, there are many factors and conditions that may have contributed to these findings. More studies should therefore be carried out investigating this issue.

Keywords: School meal, dietary habits, adolescence, public health

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Appendices

Appendix 1: The School Meal Survey (Translated from Norwegian)

Appendix 2: Coding of variables and sum scores

Appendix 3: Number of respondents reporting to have used or not used the school meal offer (%)

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List of abbreviations

DALY: Disability-adjusted life year

FFQ: Food frequency questionnaire

HBSC: Health Behavior in School-aged Children

NCD: Non-communicable disease

NIPH: Norwegian Institute of Public Health

SES: Socioeconomic status

UPF: Ultra-processed food

WHO: World Health Organization

Introduction

There are 1.3 billion adolescents worldwide, which is equivalent to 16 % of the world's population (Unicef, 2022). The World Health Organization (WHO) defines adolescence as the age between 10-19 and is a life phase transitioning from childhood to adulthood where foundations necessary for health in later life are developed (Unicef, 2022; World Health Organization, n.d). With adolescence comes puberty, physical growth, cognitive development, psychosocial changes, and increased economic, social, and emotional independence (Biro & Chan, 2022; Stang & Larson, 2012; Trew et al., 2006). In this phase, nutrition is essential for growth, and with increased autonomy on several aspects of life, diet-related decisions follow (Nasjonalt råd for ernæring, 2011; Stang & Larson, 2012). In adolescent years, dietary habits are characterized by meal skipping, high intake of sweets and soda, and high-processed foods, and many adolescents are not meeting the nutritional recommendations (Inchley et al., 2020). Eating a diet that is high in sugar and saturated fat can negatively affect brain function, while a healthy diet supports it (Muth & Park, 2021). Additionally, the intake of micronutrients has acute effects on cognitive functions (Muth & Park, 2021) and has been linked to improved memory in young adults (Hoyland et al., 2008). Eating breakfast, which adolescents often tend to skip, is associated with an acute positive effect on memory (Galioto & Spitznagel, 2016). Skipping breakfast is associated with poorer academic achievements (Vik et al., 2022). Thus, skipping meals is not considered advantageous for adolescents who spend much time at school. Further, health-related decisions in this period affect health in adulthood (Fleary et al., 2018; Inchley et al., 2020).

An unhealthy diet is one of the most critical factors in developing non-communicable diseases (NCDs), including cancer, cardiovascular disease, diabetes, and chronic respiratory diseases (World Health Organization, 2013). Between 2000 and 2019, the number of deaths caused by NCDs increased by 13% (World Health Organization, 2022b). NCD-related deaths reached 42 million in 2019, highlighting the global health concern of these diseases (GBD 2017 Diet Collaborators, 2019). A global strategy developed by WHO (2013) aims to reduce the risk of premature deaths from NCDs with 33% by 2030 (2021b), with Norway also committing to this goal. Another goal is to stop the rise of obesity and diabetes as it increases the risk of developing NCDs (Nasjonalt råd for ernæring, 2011). In Norway, this development is heading in the wrong direction (Folkehelseinstituttet, 2017). Further, childhood obesity is associated

with NCD development in adult years (Baker et al., 2007; Fuemmeler et al., 2009; Juonala et al., 2011; Weihrauch-Bluher et al., 2019).

According to WHO (2022a), every third child of school age is obese or overweight. In Norway, the prevalence is one in six (Meyer & Bergh, 2017). Thus, childhood obesity is a global health concern and a financial burden. (GBD Obesity Collaborators et al., 2017; Spinelli et al., 2019; Tremmel et al., 2017). The cause of obesity is complex. However, obesogenic environments that encourage unhealthy eating habits and a sedentary lifestyle are mechanisms attributed to the obesity pandemic (World Health Organization, 2022a). Children and adolescents who are obese tend to remain obese in adulthood (Baker et al., 2007; Inchley et al., 2020). Additionally, eating habits developed during childhood and adolescence tend to continue into adulthood (Inchley et al., 2020; Mikkila et al., 2005; Movassagh et al., 2017). Hence, establishing a healthy lifestyle is an important preventive measure for children and adolescents.

Health promotion aims to empower individuals to gain control over their health and the determinants affecting health (World Health Organization, 1986). The term refers to how societal, social, and economic conditions can be changed to positively impact public and individual health (Naidoo & Wills, 2016). Therefore, health promotion is a complex process that involves all parts of the community, and a policy that holds this focus in all sectors of society is necessary (World Health Organization, 1986). As children and adolescents spend a large part of their time in school, this is an essential setting for promoting health on several levels (Naidoo & Wills, 2016). In Norway, systematic health promotion work has been enshrined in the Public Health Act (2011). In addition, parliamentary messages and national action plans emphasize the schools' responsibility to promote health (Departementene, 2017; Meld. St. 19 (2014–2015)). Based on the foundations of health promotion, free school meals and their potential have been promoted among various professional councils and organizations worldwide (Food and Agriculture Organization, 2022; UNESCO et al., 2023). In Norway, introducing school meals has been proposed to reduce social inequality in health and the disease burden caused by diet-related risk factors (Arntzen et al., 2018; Helsedirektoratet, 2018). Additionally, it has been suggested that a free school meal may have positive effects on dietary habits (Helsedirektoratet, 2022a; Hovdenak et al., 2023)

The school can be a place where students learn about healthy eating habits through practical and theoretical education. Additionally, the school is one of many environments where children and young people interface with food through school meal programs or canteens (Raza et al., 2020), and food availability affects students' food choices (Holli & Beto, 2014). Thus, providing healthy and nutritious food options in schools is essential.
A report by an expert panel on nutrition published in 2020 suggests that the Norwegian government should impose requirements for a healthy food environment in schools (Torheim et al., 2020). Furthermore, review studies and reports have found that school meals or the meal environment itself can contribute to improving dietary habits, prevent illness and ill-health in adulthood, even out social differences in health, and improve learning (Cohen et al., 2021; Dahl & Jensberg, 2011; Hovdenak et al., 2023; Lundborg et al., 2022; Micha et al., 2018). However, findings transmissible to a Norwegian context are needed (Hovdenak et al., 2023). Nevertheless, the school meal and the potential benefits have gained attention in Norway as a school meal scheme remains to be implemented.

The Norwegian Government committed to gradually implementing a daily free school meal nationwide as part of the health-promoting and preventive public health work through the Hurdal´s platform (2021). In 2021, the strategy for health-promoting schools 2021-2022 was approved by Viken County Council. The strategy is anchored in legislation that imposes the schools' health-promoting mandate (Folkehelseloven, 2011; Opplæringslova, 1998). According to the strategy, a health-promoting school is characterized by offering a free meal (Viken Fylkeskommune, 2020). Therefore, a pilot project where school meals were implemented in 12 selected upper secondary schools in Viken County was initiated.

The School Meal Survey by the Norwegian Institute of Public Health (NIPH) is a survey examining dietary trends at school among students (Appendix 1). In the present study, results from surveys conducted in 2021 and 2022 are used as data material to examine trends in dietary habits prior to and after the pilot project.

Theoretical background

Diet quality and health

In 2019, 94 million deaths among people over the age of 25 were attributed to diet-related risks (GBD 2017 Diet Collaborators, 2019). The United Nations (2022) and WHO (2004, 2013) have prioritized this issue, and several strategies and action plans have been

implemented in Norway (Departementene, 2017; Norwegian Ministry of Foreign Affairs & Norwegian Ministry of Health and Care Services, 2019). In Norway, more than 65 000 disability-adjusted life years (DALYs) are related to poor diet quality alone (Folkehelseinstituttet, 2018). In 2016, dietary factors were the second most important cause of death, according to a report by Øverland et al. (2018). The association between diet and disease development is evident. A diet high in red or processed meat, sodium, trans fats, and beverages high in sugar increases the risk for cardiovascular disease, colon, rectal, and stomach cancer, and obesity (Nasjonalt råd for ernæring, 2011; Nordic Council of Ministers, 2014). Additionally, a diet low in fruit, vegetables, whole grains, calcium, fiber, legumes, nuts, seeds, and omega-3 fatty acids, is associated with a high mortality rate and disability-adjusted life years (GBD 2017 Diet Collaborators, 2019). Over 7000 deaths were attributed to a diet low in these food groups among the Norwegian population in 2016 (Øverland et al., 2018).

The Norwegian dietary guidelines

To prevent diet-related diseases and improve public health, national dietary guidelines have been developed. The scientific bases for the dietary guidelines are based on collected documentation that shows a convincing or probable causal link between exposure and risks (Nasjonalt råd for ernæring, 2011). The guidelines are issued by the Directorate of Health. These twelve guidelines provide information on which food groups to increase consumption of consumed more and which ones to limit (Helsedirektoratet, 2016, 24.10a). Overall, the diet should be varied and consist of lots of vegetables, fruit, berries, fish, and coarse grain products. Processed and red meat, sugar, and salt should be kept to a minimum. A balance of energy consumed and expended through activity should be maintained (Helsedirektoratet, 2016, 24.10a). It is recommended to consume at least five portions of fruits, berries, and vegetables daily to maintain a healthy diet. Half of this should be vegetables, and one portion is equivalent to 100 grams for children from ten years of age. Coarse grain products and lean dairy can be a part of the daily diet. It is recommended to consume fish for dinner two to three times a week and use it as a spread. The ideal amount is between 300-450 grams, with 200 grams being oily fish. It is recommended to opt for lean meat instead of red meat, and to choose liquid oils and soft margarine over butter and hard margarine. Food high in sodium or sugar should be limited. Daily consumption of sodium should not exceed 5 grams. For sugar, the recommendation is ten energy percent (Helsedirektoratet, 2016, 24.10b). Water should be

chosen as a thirst quencher. Lastly, it is recommended to be physically active for 30 minutes daily. Additionally, recommendations have been drawn on the composition of nutrients in the diet, including fat, protein, carbohydrates, alcohol, vitamins, minerals, and nutritional supplements (Helsedirektoratet, 2016, 24.10b). The dietary guidelines are suitable for people with elevated blood pressure or who are overweight. Further, the guidelines suit adults, breastfeeding, the elderly, children and adolescents.

Children and adolescents' dietary habits

Although the dietary advice is suitable for children and adolescents, figures show that more than half of adolescents aged 13-15 do not meet the recommendations (Haug et al., 2020). Studies across Europe, North America, and Oceania have found that children and adolescents' dietary habits are characterized by low consumption of fruit, vegetables, and legumes in addition to a high intake of sodium, soft drinks, and sweets (Inchley et al., 2020; Rosi et al., 2019; Williams et al., 2020). In addition to unfavorable dietary habits, the number of adolescents not eating breakfast is increasing (Inchley et al., 2020; Rampersaud et al., 2005). Additionally, skipping lunch tends to increase with age (Bakken, 2022; Bugge, 2007; Forskningsrådet, 2012, 2018; Hansen et al., 2016). Eating regularly and having a balanced meal rhythm is beneficial for concentration and stabilizes appetite regulation (Helsedirektoratet, 2012). Thus, skipping meals could lead to more snacking and difficulties in regulating meal size (Helsedirektoratet, 2012). Eating breakfast is associated with improved well-being, academic performance, memory, and biological markers (Burrows et al., 2017; Lundqvist et al., 2019; Rampersaud et al., 2005). Furthermore, skipping breakfast has been linked to obesity, overweight, and metabolic syndrome (Monzani et al., 2019; Ricotti et al., 2021).

Poor eating habits among adolescents have been associated with changes in cardiometabolic measures (Rocha et al., 2017). Further, dietary habits in early life affect health and the risk of developing disease in adulthood (Nasjonalt råd for ernæring, 2011). Additionally, dietary patterns formed during childhood and adolescent years, tend to persist into adulthood (Inchley et al., 2020; Mikkila et al., 2005; Movassagh et al., 2017). Thus, the eating habits of adolescents should be reversed to reduce the disease burden caused by diet-related factors.

Unfavorable dietary trends have also been observed in Norwegian adolescents and tend to increase with age. This includes reduced fruit and vegetable intake, higher consumption of soft drinks, snacks, and candy, and skipping breakfast more frequently (Bakken, 2022; Forskningsrådet, 2012; Hansen et al., 2016). In the following paragraphs, Norwegian children, and adolescents' overall dietary habits, focusing on breakfast and lunch habits, fruit, vegetables, snacks, and energy drinks, will be presented.

Breakfast

National studies have shown that the proportion who skip breakfast increases with age. Results from the Norwegian Health Behavior in School-aged Children study (HBSC) showed that 11-year-olds ate breakfast more frequently than 15-year-olds, and girls tended to skip breakfast more often than boys (Haug et al., 2020). Other studies have made similar findings. Results from a cross-sectional study showed that every fifth student at secondary school skipped breakfast (Forskningsrådet, 2018). According to the national youth survey Ungdata, almost a quarter of secondary and upper secondary school students skipped breakfast before going to school, and there was a tendency of increased breakfast skipping with age (Bakken, 2022).

Eating breakfast is associated with several positive outcomes (Burrows et al., 2017; Lundqvist et al., 2019). A study by Vik, Nilsen, and Øverby (2022) found a positive association between breakfast intake and improvement in mathematics and science among 9th graders. Conversely, being hungry was associated with reduced academic achievements. In a review from 2005, the researchers concluded that eating breakfast may contribute to improved memory, academic performance, mood, and psychosocial functioning (Rampersaud et al., 2005). However, researchers point out that these results could be confounded by other factors, but similar findings have been reported in other studies (Adolphus et al., 2016; Adolphus et al., 2013). Further, a systematic review found an inverse association between breakfast consumption and obesity, overweight, and BMI in European adolescents (Szajewska & Ruszczynski, 2010). Findings were mostly based on observational studies, and researchers emphasize that causal relationships cannot be drawn. According to the empirical evidence presented, providing breakfast in schools can enhance the concentration, learning ability, and cognitive function of adolescents.

Lunch

To maintain concentration and blood sugar levels steady, the Directorate of Health (2020, 11.12) recommends that adolescents have a regular meal frequency of 4-5 meals per day Eating lunch is part of a regular eating pattern, and it is particularly important during a school day. It is estimated that the lunch meal should make up 25% of the total daily energy intake for children and adolescents (6-18 years) (Helsedirektoratet, 2015). Thus, the meal composition and nutritional content are essential as lunch contributes to a significant part of the diet. As for breakfast, skipping lunch during school hours increases with age (Bakken, 2022; Bugge, 2007; Forskningsrådet, 2012, 2018; Hansen et al., 2016).

Figures from the Research Council (2012, 2018) showed that 59-64% of students in upper secondary schools ate a packed lunch, and 8-10% reported not eating anything. Similar results were observed in the youth survey, Ungdata (Bakken, 2022). Regular lunch consumption (7d/w) is associated with increased academic achievements among Norwegian adolescents aged 15-17 (Stea & Torstveit, 2014). A Norwegian study by Overby et al. (2013) found that regularly eating lunch (6d/w) was associated with decreased odds of self-reported mathematical difficulties. Further, eating a healthy lunch provided by the school has been associated with an overall healthier diet, including decreased intake of fast-food, snacks, and soft drinks, and an increase in nutritious food among Finnish pupils (Raulio S, Mukala K, Ovaskainen ML et al., 2004 referred in Raulio et al., 2010; Tilles-Tirkkonen et al., 2011). Similar results were observed in a Norwegian pilot project where introducing a free school meal to students aged 10-12 years for one year was associated with an increase in vegetable, fruit, and fish consumption (Illokken et al., 2017; Vik, Van Lippevelde, et al., 2019). However, the project had no impact on meal frequency or consumption of unhealthy snacks or soft drinks (Vik et al., 2020; Vik, Naess, et al., 2019).

Fruit and vegetables

Fruit, berries, and vegetables contain a range of minerals, vitamins, fiber, and bioactive compounds, while also having a low energy density (Nasjonalt råd for ernæring, 2011). Fruit and berries reduce the risk of developing several types of cancer (Nasjonalt råd for ernæring, 2011) and an inverse association between fruit consumption and type 2 diabetes has been observed (Li et al., 2015; Muraki et al., 2013; Schwingshackl et al., 2017). Further, consuming fruit in combination with vegetables reduces the risk of cardiovascular disease and metabolic syndrome (Nasjonalt råd for ernæring, 2011). Conversely, a diet low in fruit and

vegetables is a risk factor for death and DALYs and could lead to micronutrient deficiencies (Inchley et al., 2020; Nasjonalt råd for ernæring, 2011).

Several studies have found that Norwegian children and adolescents fail to meet the recommended fruit and vegetable intake. The Norwegian HBSC study found that more than half of adolescents aged 11, 13, and 15 did not meet the daily requirements for fruit or vegetables (Haug et al., 2020). The total proportion of students eating fruit and vegetables several times daily was lower than 20%. The proportion was higher among girls and the youngest. Further, high socioeconomic status (SES) was associated with higher consumption. Low consumption of fruit and vegetables has also been observed in the national dietary survey UNGKOST 3 (Hansen et al., 2016). 8th graders consumed more vegetables compared to 4th graders. On the other hand, fruit intake was highest among 4th graders. Boys had a greater intake of vegetables overall, while girls consumed more fruit.

The fruit and vegetable intake during school hours shows similar trends. A repetitive cross-sectional study by Forskningsrådet (2018) found fruit and vegetable consumption to be lowest among the oldest students, and highest among pupils in 1-4th grade. On the other hand, it was observed that the oldest students ate more salad than the youngest pupils. A study conducted by Hilsen, Eikemo, and Bere (2010) found that 60% of students (mean age 15.5) consumed fruit and vegetables less than once a week during school, and girls consumed more than boys. Students with higher education plans reported a higher intake than those without (Hilsen et al., 2010). The latest data indicates that the consumption of fruits and vegetables in schools remains insufficient. According to a study by Bakken (2022), 41% of students in lower and upper secondary schools did not eat any fruits, vegetables, or berries during school hours, and this trend increased with age.

Snacks, beverages, and energy drinks

Snacks are, in this thesis, referred to as foods high in sugar, sodium, or fat.
(Hess et al., 2016), Further, snacks are characterized by a high energy density and a low nutritional value. Candy, chips, cookies, and baked goods are foods included in this food group. Consuming foods that are energy dense, and high in sugar and fat increase the risk of obesity, which increases the risk of developing cancer and type 2 diabetes (Nasjonalt råd for ernæring, 2011). Further, the Directorate of Health (2020, 11.12) recommends limiting the intake of soda, sugary, and carbonated beverages owing to their high sugar and acid content.

Further, large amounts of energy drinks are not recommended for children and adolescents because it contains high amounts of, which can cause sleep disturbances, restlessness, nervousness, and anxiety (Helsedirektoratet, 2020, 11.12; Mattilsynet, 2011, 29.03).

Research has indicated that the consumption of unhealthy snacks, confectionery, and sugary beverages tends to increase with age, both in general and at school (Forskningsrådet, 2018; Hansen et al., 2016; Haug et al., 2020). The Ungdata survey showed that the majority of students (35-37%) consumed these foods 2-3 times per week (Bakken, 2019). A cross-sectional study by Hilsen et al. (2010) found that 33% of adolescents (mean age 15.5 years) consumed candy or chips once a week or more during school hours. Similar findings were observed for baked goods. A total of 24% reported consuming sugary soda at least once a week.

Health promotion in schools

The Norwegian school's mandate to conduct health promotion work is anchored in several legislations. First, according to the Norwegian Public Health Policy §1-1 (2011), municipalities are required to promote the health and well-being of their population, prevent illness and injuries, and reduce social inequalities. Public secondary schools and upper secondary schools are owned by the municipality and the county council, respectively (Folkehelseloven, 2011; Helsedirektoratet, 2015). Thus, schools are responsible for ensuring the health and well-being of their students, in compliance with national laws and guidelines (Departementene, 2017; Folkehelseloven, 2011; Forskrift om miljørettet helsevern i skoler, 1995; Meld. St.19 (2018-2019)).

According to the Education Act § 9 A-2, students are entitled to a school environment that is safe and health-promoting (Opplæringslova, 1998). Further, the school is responsible for the well-being and health of its students, as stated in the regulations on environmental health protection in nurseries and schools §1 (1995). The regulation emphasizes the importance of favorable social and environmental conditions. Further, by § 11, there is a requirement that the eating environment is arranged in a way that social function is maintained (Forskrift om miljørettet helsevern i skoler, 1995). The Norwegian Directorate of Health established national guidelines for school meals in 2015. The guidelines provide recommendations for mealtime management, including designated eating times, facility standards, hygiene

practices, and nutritional quality of food served or sold in the canteen (Helsedirektoratet, 2015). The purpose of these guidelines is to ensure that children and adolescents have access to nutritious food and to lessen the impact of socioeconomic disparities in lifestyle. In Norway, children are required and have a right to complete primary school, a ten-year course, per the Education Act § 2-1 (1998). Students who have completed secondary school are entitled to upper secondary education, which has a duration of three years in total (Opplæringslova, 1998, § 3-1). Hence children and adolescents spend a large part of their childhood and youth at school. Further, the number of students in Norwegian upper secondary schools in the year 2022-2023 was approximately 185 000 (Utdanningsdirektoratet, 2023).

Thus, health-promoting measures in schools be a public health initiative that will reach a large part of the population over a long period of time (Naidoo & Wills, 2016). Further, schools are a crucial arena where children and adolescents acquire essential knowledge about health-promoting behavior, which may affect diet and health (Helsedirektoratet, 2015; Oostindjer et al., 2017; World Health Organization & United Nations Educational, 2021). Therefore, school meals can be an initiative for learning and promoting favorable dietary habits.

The school meal in Norway

The school meal as an arena for ensuring the diet of children and young people has been on the agenda since the 18th century. During the 1890s, school meals were introduced in Oslo to ensure the diet of students who did not have adequate nutritional status (Bugge, 2019). In 1929, Carl Schøitz introduced the "Oslo breakfast", which consisted of milk, bread or crisp bread with margarine and cheese, fruits or vegetables, and liver oil. Children who received this meal gained weight and showed improved growth (Norum, 2014). The scheme was tested in Oslo and Bergen but ceased in 1963 in favor of the "*Sigdal breakfast*", where pupils had to bring packed lunch based on the composition of the Oslo breakfast (Andresen & Elvbakken, 2007; Norum, 2014), something that today's packed lunch culture in schools bears its marks on.

In 2020 more than 330 million children received a school meal through school meal programs (Global Child Nutrition Foundation, 2022). In Norway, school meals remain to be implemented. However, in 2022, 16% of lower secondary schools had a meal scheme, whereas 6% was of no cost to students (Kolve et al., 2022). For upper secondary schools,

approximately 50% offered a free meal in 2022 (Hovdenak et al., 2023). School meal programs are not regulated by law, resulting in a lack of consistency in the meals provided to students across schools. Further, bringing a packed lunch is part of the Norwegian food culture (Andresen & Elvbakken, 2007; Forskningsrådet, 2018; Kolve et al., 2022). However, this trend is decreasing, particularly among older students (Bakken, 2022; Forskningsrådet, 2012, 2018; Hansen et al., 2016). Students in secondary schools and upper secondary schools have the opportunity to buy lunch from canteens, shops, and other locations during school hours which could explain this trend (Helsedirektoratet, 2022a). Students who buy food during school breaks tend to consume more unhealthy snacks and carbonated sugar-sweetened beverages compared to those who do not (Gebremariam et al., 2016). Additionally, a study by Chortatos et al. (2018) found that students who purchased food from the canteen >2 times per week tended to consume more snacks and soft drinks. Further, regular canteen purchase was associated with a more frequent purchase of food in nearby shops during school hours or on the way to/from school (Chortatos et al., 2018). This corresponds to how the diet among older students appears to contain greater amounts of salt, sugar, and generally nutrient-poor and energy-dense foods. Introducing free school meals can contribute to fewer pupils choosing to buy food from other outlets and thus result in a healthier diet, given that the food offered is in line with the authorities' dietary advice.

Norway does not have a universal meal scheme, but primary and secondary schools have subsidized subscription programs for fruit, vegetables, and milk (Helsedirektoratet, 2019). The government partially funds both schemes, and the remaining costs are covered by school owners or parental payments, according to Dahl and Jensberg (2011). Participation is optional, and figures from 2022 show that three-quarters of primary schools take part in the school milk scheme (Helsedirektoratet). Sugar-free milk with added flavor and skimmed milk with 1% fat are the most sold products (Helsedirektoratet, 2022b). In 2021, a total of 12.2 million liters of milk were sold to kindergartens, primary schools, upper secondary schools, and after-school programs (Helsedirektoratet, 2022b). Approximately 10% of children in primary school receive fruit or vegetables through the school fruit scheme, and in the fall of 2022 46 000 fruit, or vegetables were distributed (Helsedirektoratet, 2022b). A national free fruit and vegetable program was implemented in secondary schools in 2007, which ceased in 2014 (Prop. 68 L (2013-2014)). Further, programs provide courses, resources, and funding for schools and kindergartens to increase seafood consumption and knowledge about healthy food among children (Helsedirektoratet, 2019, 21.09, 2022b).

The potential benefits of school meals

Introducing school meals as a structural public health initiative may have possible benefits on several outcomes. In the following paragraphs, the impact on dietary habits and academic achievements is presented.

Dietary habits and health

Several researchers and studies have suggested that school meals could act as an arena for improving children's dietary patterns (Cohen et al., 2021; Helsedirektoratet, 2015; Inchley et al., 2020; Kolve et al., 2022; World Health Organization, 2006). A systematic review by Cohen et al. (2021) showed that offering a school lunch that included fruits, vegetables, and whole grains to all students was linked to improved dietary habits. The improvements were observed particularly among students with low food security or eligible for participation in free meal schemes (Cohen et al., 2021). For breakfast, the results were mixed, which may be because of the short time of exposure in several of the included studies or the low participation rate (Cohen et al., 2021). Further, a systematic review and meta-analysis by Micha et al. (2018) found that schools providing fruit, vegetables, or a combination, increased students' habitual intake of these foods. Intake of total fats and saturated fats, both habitual and at school lunch, was lower among students attending schools with meal standards. For in-school lunch, total fat, saturated fat, and habitual fat intake decreased (Micha et al., 2018). Further, Micha et al. (2018) found that school meal standards increased habitual fruit consumption. Similar findings were observed in a Norwegian study where children attending schools with a complimentary fruit scheme reported eating fewer unhealthy snacks and soda compared to schools not providing this scheme (Øverby et al., 2012). The results were most evident among pupils with a lower socio-economic background, according to Øverby, Klepp, and Bere (2012). Additionally, two studies observed an increase in healthy food scores, including fruit, vegetables, and fish, after 6 months of free school meals (Illokken et al., 2017) and one year (Vik, Van Lippevelde, et al., 2019).

In 2011, Dahl & Jensberg published a report including a systematic review of the impact of school meals on health outcomes and learning. In this paragraph, the health aspect is presented. The review included 15 systematic reviews and 20 individual studies. According to the researchers, providing school meals could help improve the nutritional status of children

in low-income countries(Dahl & Jensberg, 2011). Additionally, offering free fruit increased the students' consumption, including in the Nordic countries. However, the health effect in the short and long term needs further investigation. Dahl & Jensberg´s main conclusion is that school meals do not have a short-term impact on health among children living in high-income nations (2011). Regarding long-term effects, there was not enough documentation to make any conclusions, and more research is needed to examine if school meals have the potential to establish healthy dietary habits in adulthood (Dahl & Jensberg, 2011).

Lastly, the researchers argue that a possible long-term effect of the school meal could be learning students to incorporate a beneficial attitude and awareness toward food from an early age. Dahl & Jensberg (2011) underlines that the focus should not only be on the food itself but also on the social aspects of a meal situation, as seen in Finland, Italy, and Japan (Oostindjer et al., 2017). School meals may contribute to developing knowledge of nutrition, beneficial dietary habits, and social interaction during the meal, in addition to the cultural aspects of food (Dahl & Jensberg, 2011). Discarding these aspects may result in the meal's full potential not being utilized.

In 2022 a Norwegian pilot study examined the possibility of implementing a warm school meal in lower secondary schools (Kolve et al., 2022). The study included five selected schools. The results showed an increase in students consuming breakfast and vegetables and a decrease in the consumption of snacks and fruit during school hours and fast food after school when a free meal was introduced. However, the researchers point out that several students did not like the food served, and some did not taste the food at all (Kolve et al., 2022). According to the researchers, regulating students' options to leave school grounds and offering a school meal may influence students' dietary habits in a positive direction. However, based on the results from the study, Kolve, Helleve, and Bere (2022) discuss that school meals' potential for improving dietary habits is uncertain, and more studies are needed.

In 2023, NIPH published a report that aimed to summarize and examine the effect of school meals (Hovdenak et al., 2023). Researchers concluded that school meals could have several benefits. NIPH points out that the school meal can, among other things, contribute to an improved diet, but that this is affected by several factors such as the food served, its quality and desire to eat the food served, age, and meal participation (Hovdenak et al., 2023). The researchers emphasize that current knowledge is dominated by international studies, while

Norwegian and Nordic studies have shown marginal effects and have a high risk of bias (Hovdenak et al., 2023). Thus, more research in a Norwegian context is needed.

In Sweden, free school meals have been required by law since 1997, but financial support has been provided since 1937 (Dahl & Jensberg, 2011). Lundborg et al. (2022) examined the long-term impact of school meals on various health outcomes, education, and economics among Swedish children exposed to school meals between 1959 and 1969. The results showed that for males, school meals provided for nine years were associated with good overall health and decreased the likelihood of being diagnosed with any disease in early adulthood by 8% (Lundborg et al., 2022). Additionally, school meals were associated with increased height in both genders. To assess any health behavior changes, mothers' smoking status was measured, but no associations were found (Lundborg et al., 2022). Researchers found that more prolonged exposure to school meals increased income by 3% and the probability of attending university by 1.5% (Lundborg et al., 2022). There is a linear relationship between socioeconomic conditions and health: the higher the socioeconomic status, the better the health (Helsedirektoratet, 2018, 30.08). Thus, Sweden's school food policy may have contributed to reducing social health differences.

A socio-economic analysis by the Directorate of Health (2022a) assessed the beneficial effects of school meals. The findings point to the fact that introducing school meals can positively affect dietary choices during school and that the effects are more significant than the costs associated with the measures (Helsedirektoratet, 2022a). Meals with porridge or cereal showed this association. According to The Directorate of Health (2022a) school meals also have a potential impact on learning, equalization of social differences, and well-being, but the effect cannot be determined. The cost and benefit calculations have a degree of uncertainty, and there is not enough data to draw conclusions (Helsedirektoratet, 2022a). Nevertheless, The Directorate of Health highlights that positive, realistic effects are linked to the school meal and therefore recommends introducing this gradually. At the same time, obtaining more information about the school meal among schools where this has already been introduced is recommended (Helsedirektoratet, 2022a).

Academic measures and cognitive function

Studies have shown that school food can improve learning, academic performance, and factors related to cognitive function. A systematic review including 47 studies (five

Norwegian) showed a positive association between school lunch and academic performance (Cohen et al., 2021). However, complimentary breakfast showed mixed findings on students' performance and attendance. Some studies found a positive impact on school attendance among children from low-income families or with low food insecurity. However, overall, the findings were mixed (Cohen et al., 2021). Dahl and Jensberg (2011) found that consuming breakfast positively impacted concentration and learning among students lacking parental support. Further, school meals did show some positive outcomes on cognition. However, the authors emphasize the importance of the social aspect of the meal itself as a contributory factor to these findings (Dahl & Jensberg, 2011). They conclude there is no basis for claiming a short-term impact on cognition and learning by introducing school meals (Dahl & Jensberg, 2011). There are few studies on academic measures and cognitive function in Norway. A quantitative study by Heim et al., including 17 students and teachers in total, reported that a free school meal improved both the learning environment and the social environment in a small Norwegian municipality. More students attended the lunch and shared the same meal, which improved social equalization (Heim et al., 2022). Similar findings were made in a qualitative study on seven 6th-graders and three teachers in a Norwegian primary school (Illokken et al., 2021). Receiving free school meals for a year was perceived to be positive for concentration, learning social skills, and the learning environment. However, researchers in both studies underline the importance of more research for broader knowledge (Heim et al., 2022; Illokken et al., 2021)

Factors influencing dietary habits

The formation of eating habits is complex as it results from multiple factors at different levels in the food system. The food system is a complex interaction between a number of components within food production, politics, economics, environment, sociocultural aspects, biology, and behavior (Raza et al., 2020). Thus, what we eat is determined by biology, psychology, parental modeling, culture, media and technology, education, agriculture, economics, politics, and the food supply chain (Gebremariam et al., 2016; Raza et al., 2020; Rozin, 2006). Further, how the environment is formed, affects how individual interacts (i.e. purchase and consume) with food (High Level Panel of Experts, 2017). Therefore, all elements in the food system are essential when it comes to the dietary choices of individuals.

The *Innocenti Framework,* developed by Raza et al. (2020), is a framework focusing on how the elements in the food systems interact, especially considering children and adolescents' health and diet. Additionally, the framework is, as stated by Raza et al. (2020), developed to guide policymakers in developing food systems that ensure children and young people a nutritious, sustainable, safe, and affordable diet. Thus, the food system can facilitate the population, especially adolescents, to make healthier food choices through this framework. The food system consists of five groups of drivers: demographic, social and cultural, political and economic, biophysical and environmental, and innovation and technological. These are factors and processes on a structural level influencing the food system's functioning in providing safe, sustainable, and affordable diets with high nutritional value (Raza et al., 2020)

The framework emphasizes four determinants of importance in the food system and the interaction between them; food supply chains, external and personal food environments, and behaviors of caretakers and youth (Raza et al., 2020). In the following paragraph, these determinants will be presented. The food supply chain refers to the chain from harvesting, production, processing, and distribution to consumption (Raza et al., 2020). How food is produced is of great importance for its nutritional value and thus for health. Food processing, including fortification, can improve the nutritional value of foods (Raza et al., 2020). Conversely, food processing can have negative consequences for health. Ultra-processed foods (UPFs) are industrially produced, energy-dense, high in salt, fat, and sugar, and has been linked to adverse health implications (Lane et al., 2022; Monteiro et al., 2019; Monteiro et al., 2013; Moradi et al., 2021). Additionally, it is a food group linked to heavy marketing (Monteiro et al., 2019). Marketing is part of the external food environment which refers to physical, political, and socio-cultural contexts where food interaction occurs (Raza et al., 2020). Adolescents are a vulnerable group particularly susceptible to advertising. Advertising Occurs physically in retail, as posters on public transport, on television, and digitally. Digital marketing is based on algorithms and thus aimed directly at the user (Uldahl & Torheim, 2023). Research has shown that marketing directed at children and adolescents influences meal preferences and dietary choices (Cairns et al., 2013; Mc Carthy et al., 2022; Qutteina et al., 2019; Smith et al., 2019). It is particularly problematic that unhealthy food is presented where children and young people encounter, such as schools and retail (Raza et al., 2020; Unicef, 2019). Pricing, availability, marketing, food quality, and safety are factors affecting the external food environment (Raza et al., 2020). Additionally, they are important determinants for the shaping of dietary choices in the household, and the personal food

environment. This includes socioeconomic circumstances, personal finances, food access, convenience, and desirability (Raza et al., 2020). In Norway, low-income families have to spend a more significant proportion of their income on food compared to high-income families (Uldahl & Bere, 2023). This reflects how the pricing of food has consequences on the financial availability of healthy foods. Additionally, marketing affects sociocultural norms (Raza et al., 2020). This may increase the acceptance of unfavorable dietary choices within the family and contribute to forming of unhealthy dietary habits. Further, friends or peers can affect food choices by increasing the desirability and acceptance of food (Raza et al., 2020).

The Innocenti framework presents several factors that influence dietary choices, and these determinants often overlap and interact with each other. Further, the factors have elements that can increase or moderate the effect on each other (Raza et al., 2020). The school meal could be an initiative that contributes to better dietary habits among adolescents by increasing the financial and physical availability of healthy food and making healthy and nutritious school food part of the food culture and thus more acceptable.

Objectives and delimitations

The object of the present study was to examine whether and to what extent a free school meal impact students' dietary habits during school hours. The data material is collected from upper secondary school students in Viken County, located in the southern part of Norway. Therefore, the present study is limited to adolescents in Viken County attending upper secondary school where most students are between 15 - 19 years of age. Based on the presented empirical and theoretical findings, the main research question was phrased:

What is the impact of free school meals on dietary habits in school among secondary school students in Viken county?

Subsidiary research questions

1. *What is the impact of free school meals on students' consumption of breakfast and lunch during school hours?*
2. *What is the impact of free school meals on students´ fruit, vegetable, and snack intake during school hours?*

Methods

About the *Free School Meal Project*

In 2020 the Strategy for health-promoting schools 2021-2023 was passed by the Viken County council (2020). The strategy aimed to develop and strengthen the health-promoting work in the county (Viken Fylkeskommune, 2020). Following the strategy, all schools must follow national guidelines for food and meals in upper secondary schools (Helsedirektoratet, 2015). Further, the food served shall be sustainable, of which 30% must be organic, and a vegetarian option must be available. As a part of the strategy, free school meals were implemented as a pilot project, named *The Free School Meal Project, and Sustainable Canteens*. The aim of the project was to determine the most efficient meal model for offering free school meals, considering the required resources and costs, and examine students' experience with these models (Matvalget & Viken fylkeskommune, n.d). All schools in Viken with a canteen could apply to join the project, and twelve upper secondary schools were selected to participate. Schools were chosen based on their project participation purposes, location, size, and educational programs (Matvalget & Viken fylkeskommune, n.d). Matvalget, an organization working on promoting and guiding businesses in serving sustainable meals, gave training and guidance to the pilot schools to reorganize the canteens within the requirements of the national guidelines. Further, the schools received information on healthy and sustainable canteen operations, as well as inspirational booklets on how to provide meals in line with the guidelines given in the strategy for health-promoting schools. Additionally, financial assistance was given to cover the food cost. Lastly, schools could choose the food meal scheme that best suited their needs. The project was initiated in January 2021 and ended in the summer of 2022.

Description of data collection and data samples

In January-February 2021 and 2022, NIPH carried out two repeated surveys named *The School Meal Survey*. The survey is a questionnaire aimed at examining socioeconomic measures, well-being, and dietary habits during school hours. The surveys are based on the *Ungdata* survey, and the *HBSC* study, which are national youth studies that address these subjects (Nilssen, 2021). The survey in 2021 was done in cooperation with Oslo municipality, and adaptations were made in collaboration with Viken County for use in the county's upper secondary schools (Nilssen, 2021). Responses from students in upper secondary schools in

Viken were used in the statistical analyses in the present study. The baseline data is from the survey conducted in 2021 while the follow-up data is from the 2022 survey.

Prior to the survey, information letters were modified and distributed to all schools in Viken County. Customized information sheets were sent to principals, school management, parents, and students, and a high participation rate was expressed as important (Nilssen, 2021). Instructions on completion of the survey were given to teachers in order for the survey to be carried out as equally as possible across classes and schools and to enable comparison of the data collected (Nilssen, 2021). Teachers were instructed to conduct the survey during class and supervise their students. Prior to starting the survey, the teacher should read a standard message providing information about the survey (Nilssen, 2021). It was emphasized that students should respond based on their normal everyday experiences without any COVID-19 restrictions (Nilssen, 2021).

NIPH was responsible for both surveys, and data were collected anonymously via Nettskjema.no. The questionnaire consisted of 28 questions (Appendix 1). Questions were close-ended, and the first part of the survey asked about gender, school, grade level, study program, and questions related to family finances and parents' educational level. Additionally, the survey included questions regarding eating habits, and students were asked how often they usually eat breakfast and lunch during a school week. If they answered no, respondents were asked to state the reason why. Further, students registered consumption of different food groups such as fruit and vegetables, cereal products high in fiber, fish, meat, chocolate and sweets, and beverages during school hours. There were questions about whether the school offered free breakfast, lunch, or fruit and vegetables. The survey included questions about whether lunch was purchased or brought from home. In addition, the survey included inquiries regarding one's overall well-being, ability to concentrate, and level of workplace tranquility. Lastly, there was an opportunity to write additional comments. The estimated survey completion was approximately ten minutes.

The baseline study was initially supposed to take place for three weeks, but the survey continued longer than planned because of the covid-19 situation at the time (Nilssen, 2021). During this period, the government introduced measures that, for many schools, led to a combination of homeschooling and physical attendance (Regjeringen, 2021, n.d). Additionally, isolation and quarantine were imposed if one were sick, and digital teaching was

carried out in several of the selected schools (Nilssen, 2021). The participation rate at baseline was 31%, while the participation at follow-up was 47%, and measures related to covid-19 were eased at this point. It is possible that the pandemic caused lower participation rates at baseline.

Description of the schools´ meal models

Of the twelve schools participating in the school meal project serving free meals, three were selected for analysis in the present study. Three schools not receiving any meals in the period were selected as control schools. Schools were selected based on the number of responses in both surveys to avoid bias, as the sample at baseline had a higher response rate than the follow-up survey. Schools with less than 100 responses in both surveys were therefore excluded. Further, the schools selected in the present study were evenly distributed across the county, with both rural and urban localizations to ensure a representative sample. Lastly, schools were selected based on the distribution of students in general and vocational courses to achieve equality between groups for comparison.

Detailed information regarding the schools' meal implementation was obtained from Matvalget which provided food waste records from the respective schools. The implementation of free school meals started at various times between schools and took place between February 2021 and June 2022. The records also contained information about what meals had been served. In 2021, all included schools in the present study were allocated funds to hire breakfast assistants to prepare and clean after breakfast as part of another project. Each school had the freedom to decide the frequency and how meals were served. This resulted in some schools serving breakfast and some offered lunch. The schools' choice of meal model will be presented in the following paragraphs. The schools in the present study are anonymized and are referred to as School 1, School 2, and School 3. All schools served free meals as breakfast, meaning a meal was offered before the start of the school day or during the first break. One of the schools served lunch additionally. The covid-19 pandemic and the following restrictions at the time of the intervention affected the ability to serve food to all students or grade levels on the same day or week. At some periods, there was no food served. Further, during the intervention, there are periods when neither food waste nor meals have been registered in the records. Additionally, due to restrictions, fewer students were able to attend school, resulting in limited access to school meals for many students. In all schools

included in this study, far fewer meals were served than there were pupils registered at the study sites. In an evaluation report, it was informed that the schools chose to test the school meals on a smaller scale, either by classes or grade levels receiving the offer by turn or selecting certain classes (Matvalget & Viken fylkeskommune, n.d). Therefore, it is essential to underline that meals were not offered to the whole school at once.

School 1 served breakfast to the students during the first break, which had a duration of 15 minutes. The breakfast mainly consisted of porridge, chia pudding, bread rolls with spread or yogurt, muesli, and some fruit. The frequency ranged between 2-5 times per week. Self-records showed that the school served fewer meals per day than there were pupils at the school. The maximum number of meals served was approximately half of the number of students at the school.

School 2 served breakfast, mainly porridge with a variety of toppings, and was offered approximately five times per week. However, it is not reported whether all pupils or grade levels had access to breakfast at the same time. Information from the school´s self-report forms shows that the school served fewer meals than there were pupils attending the school. Furthermore, the number of portions served varied throughout the period of the intervention. The school included first-year students in start-up meetings to evaluate how the measure worked and to inform students about the measure.

School 3 served students porridge and cereal for breakfast, which was offered half an hour before the start of the first class. There was room for all students in the canteen at once, but students usually ate breakfast in the classroom. In addition, a free lunch meal was offered five days a week. The lunch break had a duration of 35 minutes. Salad bar, cereal and yogurt buffets, bread varieties with spread, pasta, roasted vegetables and potatoes, soup, and noodle salad were some of the meals served. Far fewer meals were served than there were pupils at the school. At most, just over half as many portions were served as there were students.

Instrument

Preparing the data set

JMP Pro 16 was used for statistical analyses (SAS Institute Inc., 2021). After data cleaning, the data material comprised of 3651 rows and 89 columns. Schools with participants less than 100 in both surveys were excluded. Additionally, control schools offering school meals before

the start of the project were excluded. Finally, non-responses were coded as missing and excluded from analyses and descriptive statistics. Six schools were selected for the analysis; three had status as control, and three were intervention schools participating in the free school meal project. Schools receiving meals (intervention group) were compared to the baseline data from the same schools. The control schools (not receiving school meals) were compared to baseline data from the same schools to examine any changes in trends in the population.

Variables and coding

Breakfast, lunch

Breakfast frequency was obtained through the question: "*How often do you usually eat breakfast during a normal school week?"* Students were asked the same question to examine lunch consumption. The options for both questions were: 5 times a week, 4 times a week, 3 times a week, 2 times a week, 1 time a week, or I usually do not eat breakfast/lunch. Answer options were dichotomized into two groups (Appendix 2). Dichotomization simplifies statistical analyzes and the presentation of these, as well as the interpretation (Skovlund, 2017). Never eating breakfast or lunch was dichotomized as 0, and the remaining answer options were grouped as 1. This leads to a loss of information regarding variations in the data (Skovlund, 2017) and reduces statistical power (Altman & Royston, 2006). Thus, variations in breakfast or lunch frequency could not be examined. However, the number of respondents not consuming breakfast at baseline was 23%, and it was interesting to further examine this group according to the study's objective. Further, dichotomization was done based on the nutritional guidelines, stating the importance of breakfast and lunch for adolescents (Helsedirektoratet, 2020, 11.12).

Fruit, vegetables, and snacks

The frequency of the following food groups was examined and included in the analyses: Fruit and berries, vegetables and salads, and snacks (e.g., chocolate, candy, chips, salty snacks, sweet pastries). Questions regarding the frequency of these food groups were similar to those for breakfast and lunch and were dichotomized based on national dietary guidelines (Appendix 2). Intake of fruit, vegetables, coarse grain products, and water several times per day or five times per week was dichotomized as 1. The remaining response options, 4 – 1 time per week, less than 1 time per week, never, were given the value 0. Baked goods, fast food, chips, chocolate, soda (diet, regular), and energy drinks were dichotomized as follows: Several times per day, 5, 4, 3, 2, 1 time per week = 1. Less than once a week, never = 0.

Diet sum score

A sum score of healthy food and less healthy food was made (Appendix 2). The healthy food items included coarse grain products, fruits, vegetables, and water. Consuming one of the items several times a day or 5 times per week gave a score of 1. Unhealthy food items included in the score were: Fast food, baked goods, chocolate and chips, and unhealthy beverages. Chocolate and chips were merged into one variable, while regular and diet soda, energy drinks and other sugary beverages were merged into one variable. Merging was done to include all relevant variables and to have an equal number of categories in both groups, giving them equal scores. For example, consuming chocolate or chips at least once a week gave a score of -1, while drinking soda, energy drinks or other sugary beverages gave a score of -1. The sum score ranged from 4 to -4.

Socioeconomic status

Parental education was used as an indicator of socioeconomic status. In previous studies, researchers have used parental education to measure socioeconomic status, and in combination with material resources in national youth surveys (Bakken, 2019; Bere et al., 2010; Øverby et al., 2012). Several factors, including profession, income, and housing conditions, are related to SES (Syse et al., 2022). However, empirical knowledge shows that education could explain the social health gradient where higher education is associated with a healthier diet consisting of more fruit and vegetables (Dahl et al., 2014). Similar findings have also been made among Norwegian adolescents (Bakken, 2019). Further, as the objectives of the present study do not concern socioeconomic status in depth, parental education was considered a suitable method. Students were asked to provide their parents' level of higher education. The variables were dichotomized into two groups: Both parents with high education = 1, one of them = 0, neither of them = 0. The distribution of the two groups was 55% and 45%, respectively. 14% of the respondents did not know their parent's educational level or did not want to answer and were logged as missing. Additionally, there were 21 missing values.

Statistical analysis

Descriptive analysis

Cross-tabulation was used for descriptive analysis, see Table 1. Any changes between groups and between baseline and follow-up were analyzed using chi-square tests, as all relevant

variables were dichotomized. Breakfast and lunch skipping, in addition to all dietary variables, were set as dependent variables. The significance level was set to p <0,05. To further examine any changes between intervention and control groups in breakfast skipping, lunch skipping, and dietary variables, these variables were stratified by gender and parental SES (Table 2).

Linear mixed model

Changes in breakfast and lunch skipping from baseline to follow-up were analyzed using a linear mixed model with breakfast and lunch skipping and diet sum score as dependent dichotomized variables. Dependent variables were set as continuous to perform the analysis. In the model, SES, gender, school intervention status, and time were set as independent variables. Additionally, it was desirable to examine whether breakfast or lunch consumption was dependent on the introduction of school meals and to examine changes between baseline and follow-up. Further, school status and time were crossed to investigate whether there was a difference in development between breakfast and lunch skippers and dietary scores from 2021 to 2022 and between intervention and control schools. Further, all schools were nested as random effects to model random variation within schools.

Ethical considerations

The data from *The School Meal Survey* was anonymized. Further approvals from relevant committees were therefore not required which were clarified by NIPHs own data protection representative. The survey was carried out in upper secondary schools where the age range is from 15-19 years. Consent to participate in research can be given to children and young people from the age of 15 when the information is not of a personally sensitive nature (SIKT, n.d). No such information was collected in the surveys as the survey was anonymous. Further, information about schools included in the study was anonymized. The surveys were voluntary, and it was possible to skip answers. Students received information about the survey, as well as its purpose and privacy protection, via teachers, through information letters, and on the front page of the online questionnaire (Nilssen, 2021). It was informed that participation in the survey was considered consent. To gain access to the data sets, a data processor agreement was signed with NIPH. The agreement provides guidelines for how the data should be processed and proper storage. The data has been securely stored while ensuring confidentiality. Data will be deleted after the end of the project.

Results

Study sample – Characteristics

As shown in Table 1, the study sample at baseline consisted of 1671 respondents in total, with an approximately even distribution of respondents from control schools (n=834) and intervention schools (n=837). In the follow-up study, the total number of responses was 1980, whereas the number of respondents in the control group was higher compared to the intervention group (n=1273 vs. n=707). The total distribution of respondents with high parental SES was 55% at both points. The proportion with high SES was somewhat higher in the control groups at both time points. For gender distribution, the proportion of girls was 58% at baseline and 57% at follow-up. Chi-square tests revealed no significant difference in gender, SES, or study choice from baseline to follow-up.

At baseline, no significant differences between groups in skipping lunch or breakfast or for dietary variables were observed. The table shows that approximately one-fifth of the total sample (23%) skipped breakfast during school weeks, both in 2021 and 2022. Minor differences were observed between the intervention groups and control groups, but the results were not significant. At baseline, 22% in the intervention group skipped breakfast, and the proportion was 25% in the control group. At follow-up, the proportion was 21% and 24%, respectively. From 2021 to 2022, the total proportion of lunch skippers was reduced from 5% to 4%. At baseline, the number of students skipping lunch was slightly lower in the intervention group compared to the control group (4% vs. 5%), but not significant. At follow-up, the proportion of students skipping lunch in the intervention group increased from 4% to 5%. Lunch skipping decreased in the control group from 5% to 4%. The findings were not significant.

As observed in other studies, the number of students consuming fruit and vegetables daily was low. Higher consumption of fruit and vegetables was observed in the intervention schools at both points. Compared to baseline, total fruit intake at follow-up decreased from 20% to 18%, and the decrease was higher for the control group. However, the results were not significant. A similar trend was observed for vegetables. The vegetable intake was 19% in the intervention schools at baseline and follow-up. In the control schools, daily vegetable intake decreased from 17% to 13%, and the difference was significant (p=0.0237). Students from intervention schools reported a higher intake compared to the control schools at follow-up

(19% vs. 13%) (p=0.0009). For fast food (kebab, burgers, sausages, noodles, etc.), 40% of the students in control and intervention schools at baseline reported eating from this food group either several times per day or between 1-5 days per week. At follow-up, the total intake increased to 43%, but the result was not significant. However, in 2022 the intake was significantly higher in the control group compared to the intervention group (45% vs. 39%) (p=0.0081).

The table shows the intake of snacks, including chocolate, chips, salty snacks and baked goods several times per day or 1-5 days per week. Total consumption of snacks increased from 2021 to 2022, but the results were not significant. At baseline, the intervention group had a higher snack intake compared to control schools (62% vs. 58%). This trend continued at follow-up, with 66% of the intervention schools reporting snack intake at least once per week. For the control group, the proportion was 61%. The results were not significant at either point. Intake of soda, sugary drinks, and energy drinks several times per day or 1-5 days per week was 73% at baseline and 74% at follow-up. As for snacks, the intervention group had a higher consumption compared to the control group. At follow-up, intake was significantly higher compared to the control group (p=0.0375). For water, overall intake increased from 2021 to 2022. However, water intake was significantly higher in the control group at follow-up (78% vs. 74%, p=0.0170).

Changes in breakfast and lunch frequency and dietary variables

All variables were stratified on gender and SES, to examine distribution in subgroups (Table 2). The table shows the frequency of breakfast and lunch skipping during a school week (five days). Girls had a higher tendency to skip breakfast than boys. Among students attending intervention schools, 23% of girls skipped breakfast, and a minor decrease in this trend was observed at follow-up (-2%). For the control group, girls skipping breakfast increased from 26% to 27%. For boys, a decrease in breakfast skippers in the control group and an increase in the intervention group were observed. Skipping breakfast was associated with lower SES. However, there was a decrease in breakfast skippers from 2021 to 2022 in both groups, and the decrease was higher in the control group. For students with high parental SES, skipping breakfast increased in both groups. As for breakfast, girls had a slightly higher tendency to skip lunch compared to boys. An increase in skipping lunch from 2021 to 2022 was observed in the female intervention group (3% vs. 5%), but not among males. No differences in lunch

frequency were observed in any subgroups in the control groups except from the low SES group, where lunch frequency increased by 4%.

Table 1. Description of the study sample and main variables (% if not specified otherwise).

	2021				2022				
	All	Intervention	Control	P[6]	All	Intervention	Control	P[6]	p 21-22[6]
Schools	6	3	3		6	3	3		
Eligible pupils (n)	5406	1656	3750		4220	1626	3752		
Participating pupils (n)	1671	837	834		1980	707	1273		
Participation rate	31	50	22		47	44	34		
Girls	58	53	63		57	51	60		0.3705
High SES	55	53	56		55	52	56		0.9345
Preparatory studies	78	82	75		79	81	78		0.5735
No breakfast 5d/w	23	22	25	0.1446	23	21	24	0.2484	0.8002
No lunch 5d/w	5	4	5	0.2838	4	5	4	0.7624	0.7026
Fruit[1]	20	21	19	0.3514	18	20	17	0.1313	0.2018
Vegetables[1]	18	19	17	0.3598	15	19	13	0.0009*	0.0237*
Fast food[2,3]	40	40	40	0.8230	43	39	45	0.0081*	0.0957
Snacks[2,4]	60	62	58	0.1361	63	66	61	0.0584	0.0573
Soda, sugary beverages, energy drinks[2,5]	73	76	71	0.0682	74	77	73	0.0375*	0.6809
Water[1]	75	76	74	0.3098	77	74	78	0.0170*	0.3526

[1] Several times per day, 5 days per week [2] Several times per day, 1-5 days per week [3] Included burgers, sausages, instant noodles etc. [4] Included chocolate, candy, chips and salty snacks, and baked goods [5] Includes lemonade, iced tea/coffee, chocolate milk, and other beverages with sugar. [6] Tested with Chi-square *Significant change, $p < 0.05$

For the consumption of fruit and vegetables, the table shows the proportion of daily intake or intake several times per day during school hours. Overall, daily fruit and vegetable intake at school was low. Girls reported higher fruit consumption than boys. Overall, approximately 20% of girls reported daily intake. In the control group, there was a decrease in consumption from baseline to follow-up, whereas, in the intervention group, fruit intake increased from 23% to 25%. For boys, opposite results were observed. Boys in the control group increased consumption by 2%. In the intervention group, consumption decreased by 4%. In intervention schools, no changes were observed in fruit intake among students with high SES. Students

with low SES decreased their intake by 2%. In the control schools, fruit intake increased in the low SES group (2%) and decreased in the high SES group (-4%).

Girls reported higher consumption of vegetables, but only in the intervention schools. Among the control schools, vegetable consumption decreased from 2021 to 2022 for both genders. For female students in intervention schools, an increase in vegetable consumption was observed at follow-up, while it decreased for boys. High parental SES was associated with higher fruit and vegetable consumption. However, a decrease in intake from 2021 to 2022 was observed in the control schools but not in the intervention schools, no changes were observed. Vegetable intake increased by 1% among students with low SES in both groups.

Fast food intake, including burgers, instant noodles, and sausages, was higher among boys, and overall, more than 40% reported consuming such foods at least one time per school week. Similar findings were observed for students with low parental SES. From 2021 to 2022, fast food intake decreased among students with high parental SES and girls in intervention schools. In control schools, consumption increased among all subgroups. Overall, the consumption of snacks during school hours was high. In the intervention schools, 60% or more consumed snacks at least one day per school week in all subgroups, while the proportion was somewhat lower in the control schools. Snack consumption increased from 2021 to 2022 in all subgroups except for boys in control schools. Further, the increase was higher in the control schools. Low parental SES was associated with higher snack intake. For intake of beverages, see Appendix 6.

Changes in breakfast and lunch frequency and diet sum score – Multilevel mixed model

Table 3 shows changes in breakfast and lunch frequency and diet sum scores by gender, parental SES, school status, and from 2021 to 2022. The results are based on a multilevel linear mixed model with breakfast, lunch, and diet sum scores as dependent variables. The parameter estimates represent a change in one independent variable against dependent variables. For gender, the table shows that breakfast frequency was lower for girls compared to boys (-2%), and the difference was significant (p=0.0108). This also applied to students with low SES compared to high SES, where the estimate was -3.7% (p=<0.001).

Table 2. Change in proportion of students reporting skipping breakfast, or lunch 5 d/week, and frequency of eating selected food groups during school hours between 2021 and 2022 by gender and parental SES. Results are presented in percentages and 95% confidence intervals).

	Intervention			Control		
	2021 (95% CI)	2022 (95% CI)	Change 21-22	2021 (95% CI)	2022 (95% CI)	Change 21-22
No breakfast 5d/w						
Girls	23 (19 – 27)	21 (17 – 25)	-2	26 (22 – 30)	27 (24 – 31)	1
Boys	20 (16 – 24)	22 (18 – 27)	2	23 (18 – 28)	18 (15 – 22)	-5
High SES	16 (13 – 20)	19 (15 – 24)	3	19 (16 – 23)	21 (18 – 25)	2
Low SES	27 (22 – 32)	23 (18 – 28)	-4	32 (27 – 37)	26 (22 – 30)	-6
No lunch 5d/w						
Girls	3 (2 – 5)	5 (3 – 7)	2	5 (4 – 8)	5 (3 – 6)	0
Boys	5 (3 – 8)	5 (3 – 8)	0	4 (3 – 7)	4 (2 – 6)	0
High SES	3 (2 – 5)	4 (2 – 6)	1	4 (2 – 6)	4 (3 – 6)	0
Low SES	5 (3 – 8)	5 (3 – 9)	0	7 (5 – 10)	3 (2 – 5)	-4
Fruit[1]						
Girls	23 (19 – 27)	25 (21 – 30)	2	22 (18 – 26)	19 (16 – 22)	-3
Boys	19 (15 – 23)	15 (11 – 19)	-4	14 (11 – 19)	16 (13 – 19)	2
High SES	22 (18 – 27)	22 (18 – 27)	0	23 (19 – 28)	19 (16 – 23)	-4
Low SES	20 (16 – 25)	18 (14 – 23)	-2	15 (11 – 19)	17 (13 – 20)	2
Vegetables[1]						
Girls	19 (16 – 23)	22 (18 – 27)	3	17 (14 – 21)	13 (11 – 16)	-4
Boys	17 (14 – 22)	15 (12 – 20)	-2	17 (13 – 21)	13 (10 – 16)	-4
High SES	20 (16 – 24)	20 (16 – 25)	0	21 (17 – 25)	15 (12 – 18)	-6
Low SES	17 (13 – 22)	18 (14 – 22)	1	12 (9 – 17)	13 (10 – 16)	1
Fast food[2,3]						
Girls	36 (32 – 41)	34 (29 – 39)	-2	38 (34 – 42)	43 (40 – 47)	5
Boys	43 (38 – 48)	44 (39 – 49)	1	46 (41 – 52)	48 (43 – 52)	2
High SES	37 (33 – 42)	33 (28 – 39)	-4	37 (33 – 42)	46 (42 – 50)	9
Low SES	41 (36 – 47)	43 (38 – 49)	2	44 (39 – 50)	45 (40 – 49)	1
Snacks[2,4]						
Girls	62 (58 – 67)	66 (60 – 70)	4	57 (53 – 61)	63 (34 – 41)	6
Boys	60 (55 – 65)	65 (60 – 70)	5	60 (54 – 65)	59 (55 – 63)	-1
High SES	60 (55 – 65)	63 (57 – 68)	3	54 (49 – 59)	60 (56 – 64)	6
Low SES	65 (59 – 70)	67 (61 – 72)	2	63 (57 – 68)	64 (60 – 69)	1

[1] Several times per day, 5 days per week [2] Several times per day, 1-5 days per week [3] Included burgers, sausages, instant noodles, etc. [4] Included chocolate, candy, chips, salty snacks, and baked goods. SES: socioeconomic status.

Students at control schools showed a decreased tendency to eat breakfast by 1.7%, compared to pupils in schools with school meals (not significant). Furthermore, the analysis shows that the proportion who ate breakfast at baseline was lower than at follow-up (-0.3%), but not significant. When including the time x school status interaction, the results showed that there was a small difference in breakfast frequency from 2021 to 2022 between intervention and control schools (-0.3%). However, the results were not significant, but the findings indicate that school meals had a positive impact on students in the intervention schools and that the difference occurred at follow-up. For lunch frequency, estimated differences were observed. However, none were significant, and the confidence intervals crossed the null value for all variables, indicating no association.

The estimated values for the diet sum score, which indicates how healthy the diet is, showed that girls had a significantly higher diet score (8.9%) compared to boys (p=0.0075). Further, students with low parental SES had a lower diet score compared to students with high parental SES (-16%) (p=>0.0001). The results showed that compared to intervention schools, students from control schools had a lower diet score (-1.4%), however, the results were not significant and confidence interval overlapped, indicating no true difference. As for breakfast and lunch frequency, there were no significant results when time x school status interaction was included.

Table 3. Changes in breakfast and lunch frequency, and diet sum scores by gender, parental SES, school status and from 2021 to 2022.

	Estimate	SE	p	Lower 95% CI	Upper 95% CI
Breakfast					
Gender [girls]	-0.02	0.008	0.0108*	-0.035	-0.005
SES [low]	-0.037	0.008	<0.001*	-0.052	-0.022
School status [control]	-0.017	0.013	0.2633	-0.054	-0.002
Time period [2021]	-0.003	0.008	0.7292	-0.018	-0.013
Time period [2021/2022]*school status	-0.003	0.008	0.6658	-0.019	-0.012
Lunch					
Gender [girls]	-0.002	0.004	0.6493	-0.009	0.006
SES [low]	-0.006	0.004	0.0952	-0.013	0.001
School status [control]	-0.0002	0.006	0.9769	-0.016	0.017
Time period [2021]	-0.001	0.004	0.8826	-0.008	0.007
Time period [2021/2022]*school status	-0.006	0.004	0.1370	-0.013	0.002
Diet sum score					
Gender [girls]	0.089	0.033	0.0075*	0.0238	0.155
SES [low]	-0.16	0.033	<0.0001*	-0.224	-0.1
School status [control]	-0.014	0.099	0.8931	-0.267	0.296
Time period [2021]	0.011	0.034	0.7365	-0.055	0.078
Time period [2021/2022]*school status	0.029	0.034	0.3994	-0.038	0.095

Breakfast: 5d/w. Lunch: 5d/w. Diet sum score is based on intake of healthy (fruit, vegetables, coarse grain products, water several times a day, 5 d/w) and unhealthy food items (fast food, snacks, chocolate, and soda, several times a day, 1-5 d/w), SES: Socioeconomic status. *Significant change, $p < 0.05$.

Discussion

Summary of results

The present study examined the impact of free school meals on dietary habits in school, including breakfast and lunch habits and intake of fruit, vegetables, snacks, fast food, and various beverages among secondary school students in Viken County. Results from the linear mixed model showed no significant changes in breakfast or lunch frequency or in diet sum scores except from breakfast frequency which was significantly lower for girls and for students with low SES. However, the analysis showed a negative tendency for breakfast frequency for all variables, including control schools and baseline, indicating that control

schools had a higher tendency to skip breakfast and skipping breakfast was more frequent at baseline for both control and intervention groups. Further, the time x school status interaction showed a small negative estimated effect, indicating that breakfast frequency was lower in the control group compared to the intervention group from baseline to follow-up. Further, the confidence intervals did not include the value zero, indicating the true value within these intervals (Webb et al., 2017). Additionally, the true values are more likely to be located in the center of the interval (Webb et al., 2017). Thus, the true estimate for time x school status interaction is less likely to be zero. Additionally, the width of the confidence interval for this interaction is considered small in range, indicating high precision. Therefore, these findings could be of practical relevance (Fethney, 2010). Regarding lunch frequency, a negative tendency for all variables was observed. Estimated values showed that girls had a higher sum score compared to boys, and students with low parental SES had a lower score. This corresponds to the results in Table 2, which showed that girls and students with high SES consumed more fruit and less fast food, but higher snack intake. However, the regression analysis showed no significant findings, and confidence intervals contained the null value for all variables, indicating no difference between groups.

As presented in Tables 1 and 2, there were small and inconsistent changes in breakfast and lunch consumption from 2021 to 2022 and between groups. More students reported skipping breakfast than lunch, and girls tended to skip breakfast and lunch more often than boys. Additionally, low parental SES was associated with more frequent skipping of breakfast and lunch. From 2021 to 2022, vegetable intake decreased in all subgroups in the control schools, but not in the intervention school except the male group. Overall fruit consumption decreased. For subgroups, findings were mixed. Further, low parental SES was associated with less intake of fruit, and vegetables and more intake of snacks, fast food, and sugary beverages. From 2021 to 2022, the overall intake of unhealthy foods increased. For fast food, the control group had a significantly higher intake compared to schools receiving school meals (Table 1). Overall, consumption of sugary beverages increased, but findings were mixed when stratified on subgroups.

Discussion of the results against previous findings

There are few Norwegian studies that have examined the importance of school meals on adolescents eating habits, especially during school hours. Previous research has shown mixed

results regarding the effect of school meals on dietary habits, and researchers underline that more research is needed to be able to draw clear conclusions (Dahl & Jensberg, 2011; Hovdenak et al., 2023; Kolve et al., 2022). Further, the Norwegian studies investigating school meals are of short duration. To observe the effects of dietary changes in the population, time is essential. Few studies that could be relevant to a Norwegian context have examined the long-term effect of school meals on eating habits and health. Results from a Swedish cohort study by Lundborg et al. (2022) showed that male students who had been exposed to school food throughout a nine-year school run had better health and a reduced risk of being diagnosed with any form of disease in early adulthood. In addition, height increased for both genders. This may be due to a focus on the nutritional content of school meals, as well as the diet's direct health-promoting and preventive effect on disease (Lundborg et al., 2022; Nasjonalt råd for ernæring, 2011). In contrast, no associations were found between school meals and the development of cancer and cardiovascular disease when the population's age was 40-60 years, indicating that the nutritional impact had no influence. On the other side, to measure whether the school meals led to changes in behavior, smoking status was assessed, and no associations were observed. However, as Lundborg et al. discusses, smoking status does not provide a complete picture of health habits and lifestyle, and markers to measure dietary habits were lacking in this study. Thus, more studies are needed to make conclusions regarding the long-term effects of school meals on eating habits (Dahl & Jensberg, 2011).

Studies conducted in Norway have provided inconsistent results regarding the impact of school meals on meal frequency and dietary habits. The present study did not find significant evidence that introducing school meals positively impacted students' breakfast or lunch frequency or dietary habits. However, the time x school status interaction showed improvements in breakfast frequency, indicating that the results could be of clinical significance. The following paragraphs will discuss these findings in comparison to previous studies, with a focus on results from research in Nordic countries.

Breakfast and lunch frequency

With serving free breakfast, an increase in breakfast frequency was expected in the intervention schools as the number of breakfast skippers at baseline was relatively high, and all included schools had this offer. In the present study, breakfast frequency was significantly lower for girls ($p=0.0108$) and pupils with low parental SES ($p=<0.001$) (Table 3). This

corresponds to previous findings (Bakken, 2022; Haug et al., 2020; Jensen, 2020; Meld. St. 19 (2014–2015)) However, no significant increase in breakfast frequency was observed. Further, as shown in the descriptive analysis the differences between the intervention and control groups were mixed (Table 1). The results from the linear mixed model (Table 3) showed slight indications that breakfast frequency was lower in the control group at baseline and in the time x school status interaction. The findings were not significant, however, they are of interest. Studies conducted in Norway have either shown similar outcomes or minimal impact from such measures. Kolve et al. (Kolve et al., 2022) observed a 5% increase in breakfast frequency at home or at school when a free school meal was introduced. However, the study had a short duration time (10 days). Likewise, breakfast frequency increased among 10th-grade students receiving school breakfast for four months (Ask et al., 2006). However, they returned to their previous habits once the intervention was finished and the sample size was small (n=14) (Ask et al., 2006). A study by Vik, Naess, et al. (2019) examined the implementation of a free school meal on meal frequency among students aged 10-12 years. The results showed that introducing school meals for one year had no impact on meal frequency, including breakfast and lunch. The researchers emphasized the importance of conducting studies with larger sample sizes, as the study included 164 students. Additionally, a meta-analysis by Cohen et al. (2021) observed mixed findings when school breakfast was introduced. The researchers discuss that the findings may be due to low breakfast participation (Cohen et al., 2021). In Finland, where free meals are implemented, a higher participation rate was observed among the youngest students, while older students between the age of 13-15 tended to skip the school meal (Pellikka et al., 2019). Conversely, in Sweden, a high participation rate in school meals among students both in primary schools and secondary schools has been observed (Osowski et al., 2015; Rasmussen et al., 2004). Even though school meals are implemented in these countries, an assessment of school meals is still needed (Bere & Stea, 2017).

In the present study, no significant changes were observed for lunch frequency or diet score. Additionally, the confidence intervals of all variables overlapped, indicating no difference. These results contrast with the findings by Cohen et al. (2021), where school lunch was associated with an improvement in meal participation and dietary quality. However, eight of the 47 included studies were most relevant to the Norwegian situation as they were Danish or Norwegian. The findings from the Norwegian studies have been presented and discussed (Ask et al., 2006; Ask et al., 2010; Illokken et al., 2017; Vik, Naess, et al., 2019; Vik, Van

Lippevelde, et al., 2019). One of the studies from Denmark found that free school lunches for three months were associated with a higher intake of vegetables, fish, potatoes, eggs, and beverages among pupils aged 8-11 years (Andersen et al., 2014). Another study from the same project found no associations between a free school lunch and school attendance (Laursen et al., 2015). Sabinsky et al. (2019) found that a free school meal was associated with an improvement in overall meal quality scores among Danish students aged 7-13. Intake of vegetables, whole grains, and fish increased, and consumption of total fat, saturated fats, and snacks decreased (Sabinsky et al., 2019). The findings are noteworthy because, like Norway, Denmark does not provide a school meal program, and students typically bring their own lunches to school (Andersen et al., 2015; Dahl & Jensberg, 2011). However, these observations were made in primary school students, who typically consume more fruits and vegetables and fewer snacks compared to older students. Thus, the studies included in the systematic review by Cohen et al. and their relevance to Norwegian conditions should be interpreted regarding the context and the countries where the studies took place.
The findings in the present study may be a result of several factors. First, these findings may be due to the school's choice of meal model and data collection. The schools served meals to different grades and to different classes within the grade levels as a test arrangement. However, all students were asked to participate in *The School Meal Survey*. Thus, exposure to school meals has been uneven among the students responding to surveys. Second, the results showed that approximately half of the students at schools with free breakfast chose to make use of the breakfast offer (Appendix 3). This applied to two of the schools, while in the third, the proportion was 18%, but the sample size was the smallest (n=104, data not shown).

Next, in both surveys, students had the opportunity to elaborate on why they skipped breakfast. Of those who chose to answer, a large proportion answered that they did not have time or lacked appetite in the morning (data not shown). This coincides with previous studies (Hearst et al., 2016; Olsta, 2013; Reddan et al., 2002; Shaw, 1998). In the follow-up survey, students had the opportunity to comment on why they did not take advantage of the free breakfast offer. Most answered that they did not like the food, that they were not hungry in the morning, or that they ate at home. Some students reported that they could not eat the food due to allergies. One of the schools chose to serve breakfast half an hour before the start of school. This may help to explain the low meal participation indicating that most students lacked hunger in the morning. It can also be explained by a lack of time and logistics. Many students rely on transport to get to school, and a long way to school gives them the right to a school

shuttle, preferably by bus (Utdanningsdirektoratet, n.d). In 2022, over 20,000 pupils in upper secondary schools in Viken County had the right to school transportation (Statistisk sentralbyrå, 2023). Thus, a large proportion of pupils are dependent on public transport timetables and may not prioritize traveling earlier to eat food at school. Additionally, this school served lunch, where the participation rate was significantly higher (74%) (Appendix 3), which supports these theories. On the other hand, meal participation was lowest at the school that served breakfast in the first recess. A reason for this could be that students did not taste the food, or they chose to do other activities during the break.

Another explanation could be that students were unsatisfied with the food served. Taste was found to be the most important factor when making dietary choices among the respondents (Appendix 4a). For breakfast, porridge was mainly served by all three schools, while one of the schools had some varieties with yogurt or bread rolls. In a study by Kolve et al., (2022), where oatmeal, among other dishes, was served as lunch, about half of the students used the offer and reported liking porridge. However, 30% reported that they liked the school food less than what they usually eat, and the authors observed that many did not want to taste the food. Other studies from Norway and Nordic countries have found that a large number of students prefer eating a packed lunch rather than a free school meal. For instance, a Norwegian cross-sectional study found that 48-60% of students in a secondary school ate a packed lunch instead of a free lunch provided by the school (Bjørndal et al., 2020). Studies from Finland, a country with school meals implemented, report that 10-30% of students do not eat school meals (Raulio et al., 2010), and there is a tendency for older students to skip these meals (Pellikka et al., 2019). The main reason is disliking the food offered (Raulio et al. (2007) in Pellikka et al., 2019). On the other side, a high meal participation rate (87%) has been observed in Swedish students in 8th and 9th grade located in counties in the Stockholm area (Rasmussen et al., 2004), but over half of the total sample (n=3107) never or rarely thought the food was good (Rasmussen et al., 2004). Liking the food that is served is essential if school meals should be implemented as a measure to improve dietary habits. Further, this has been emphasized in a review by WHO (World Health Organization, 2021a). Additionally, involving the pupils in the design of the school food offer to make use of their autonomy can solve this challenge (Oostindjer et al., 2017). Lastly, food allergies and other considerations should be taken into account, making the offer available for all students.

Dietary score

As for breakfast and lunch frequency, no significant improvements were observed in the students´ dietary scores (Table 3). As previously discussed, this may be due to a low participation rate. Another important point is that the schools mainly served porridge for breakfast. One school served fruit occasionally. The student's diet was assessed by a diet sum score based on *The School Meal Survey.* The diet sum score included fruit, vegetables, coarse grain products, and water intake, contributing to a higher score. Conversely, consumption of snacks, chocolate, buns, and sugary beverages resulted in a lower score. As the breakfast mainly consisted of oatmeal, the expected effect on the diet score was minimal. This is because the dietary score consisted of three variables that were not included in the breakfast offer, including fruit, vegetables, and water. Thus, this may explain the results in the regression analysis.

The school serving lunch in addition to breakfast, had a varied lunch menu, including vegetables, soups, pasta, and a salad bar. Older students eat more foods with a high content of fat, sugar and salt, and this was also the case in the study sample of the present study. Thus, it was expected that the introduction of lunch would have a positive impact on diet scores. In addition, meal participation was higher at lunch than at breakfast. As there was only one school that served lunch with a larger offer of vegetables, a separate regression analysis was carried out for this school (Appendix 5), where all control schools were included for comparison. The diet score was significantly higher in the control schools. Similar findings were observed when compared to only one control school with a matching participation rate and localization (data not shown). However, no significant difference in the time x school status was observed. Additionally, confidence intervals overlapped, indicating no effect.

These findings stand in contrast to a Norwegian study investigating the impact of a project where a free school meal was served for a year. The results from the study showed that the intervention group ate more fruit, vegetables, and fish and lunch compared to the control group (Illokken et al., 2017). However, as the authors point out, a large proportion of the sample stated that they never ate baked goods, noodles or biscuits in the school meal, which indicates that there were few pupils who initially ate unhealthy foods at school (Illokken et al., 2017). Further, this study examined the effect after half a year and not after ending the project. Similar results were shown in a study from the same project (Vik, Van Lippevelde, et al., 2019). A positive impact on healthy food scores at school, including fruit, vegetables, and

fish, was observed after five months and after one year, compared to the control group (Vik, Van Lippevelde, et al., 2019). No significant changes after five months and one year were observed. A third study from the project observed an increase in the weekly intake of vegetables being eaten on sandwiches, but overall consumption of fruit or vegetables did not increase after a year (Vik et al., 2020). Further, no effect on the consumption of unhealthy snacks and soft drinks was observed. This study examined the effect of the project after a year, and in contrast to the findings by Vik, Van Lippevelde, et al. (2019), the impact was less effective. The findings from these studies are interesting, however, the sample in this project consisted of children between 10 and 12 years of age. This an age group whose dietary habits are characterized by a higher intake of fruit, and vegetables and less consumption of unhealthy foods such as chocolate and sweets compared to students in higher grade levels (Forskningsrådet, 2018; Hansen et al., 2016; Haug et al., 2020). Thus, the findings should not be generalized to students in upper secondary schools.

There are few Norwegian studies that have examined school meals among adolescents of older age. A study by Ask et al. (2010) examined the implementation of a free school meal on dietary habits among 9th graders. The results showed no improvement in the intake of fruit, vegetables, whole grain bread, snacks, or sugar-sweetened beverages. However, the intervention had a duration of 4 months, and it is uncertain whether this is enough time to observe any individual changes in dietary habits (Ask et al., 2010). Further, the study had a small sample size (n=58), and the proportion of students bringing a packed lunch 4-5 days per week was 77%, indicating healthy meal practices were already established. A study among 531 Finnish adolescents (aged 11-16) showed that under half of the total sample ate the main dish provided by the school 3-4 days per week (Tilles-Tirkkonen et al., 2011). Further, the intake of snacks, including chocolate and baked goods was high and did not differ between students regularly participating in the school meal and those who rarely participated (Tilles-Tirkkonen et al., 2011). Further, vegetable intake was low in both groups, indicating that school meals did not impact unhealthy dietary habits related to snacking.

Timing of implementation

Another aspect of this study that may have affected the results is the timing of implementation. The introduction of free school meals was done at a time when there were restrictions due to the covid-19 pandemic. This led to increased student absences due to

illness and closed schools. In addition, the pandemic and the restrictions that came with it led to the food service ceasing for periods for all included schools. Thus, the exposure to school meals has been uneven and may have contributed to the present results. Additionally, studies have shown that the diet among children and adolescents changed during the pandemic. A systematic review found mixed results, where 6 out of 10 included studies observed increased snack intake (Mignogna et al., 2021). Similar findings were made in Norway, where total sugar intake and consumption of baked goods, sweets, chocolate, and energy drinks among 14-year-olds increased (Brantsæter et al., 2023), which correlates with findings in the present study (Table 1). In addition, the study by Brantsæter et al. (2023) showed that the proportion who ate breakfast decreased, especially in the period March 2021 to June 2022. This was the same period as the pilot project took place and could explain the findings in the present study. However, the sample in the study was not representative of the population as the sample consisted of a larger proportion of participants with high SES (Brantsæter et al., 2023). Further, the researchers discuss that the findings could be a result of the sugar tax being abolished in 2021 (Brantsæter et al., 2023; Folkehelseinstituttet, 2023, 19.01).

The interaction between factors across the food system

How dietary behavior is established, developed, and influenced is a complex interaction between factors in the environment, in the community, and at individual levels. Why implementing free school meals did not show any changes in dietary habits in the present study can be explained by several factors, as previously discussed. The Innocenti framework illuminates how these factors influence eating habits among adolescents and how the factors interact with each other (Raza et al., 2020). The framework thus explains the complexity of eating habits and food choices in a target group that faces many challenges. In this section, the findings from this study will be explained considering this framework.

The results from this study indicate that many students did not choose to use the school meal due to several factors. These factors included a lack of time, or hunger in the morning, they ate at home, disliking the food served, food allergies or they brought their own packed lunch. It is also plausible that pupils choose to buy food from nearby shops. Diet and meal rhythm are habits that are formed at an early age and are largely influenced by their parents and their behavior (Raza et al., 2020). Eating habits are established at an early age, and parents have a great influence on how eating habits develop (Mahmood et al., 2021; Scaglioni et al., 2018).

As eating habits are mainly learned from one's parents, their knowledge of diet, preferences, habits, education, and the home environment will influence children's dietary habits (Raza et al., 2020). Bringing a packed lunch or skipping breakfast can be such a learned habit. It is well documented that people with low SES have a poorer diet compared to people with high SES and have a greater tendency to skip breakfast (Dahl et al., 2014). This also applies to adolescents of parents with low SES (Samdal et al., 2012). The findings in this study were consistent with this trend. One possible explanation for this phenomenon is that people with a high SES have more knowledge about dietary guidelines (Skardal et al., 2014). This can be explained by the fact that a high level of education provides better access to health-related information, which in turn contributes to making choices that are positive for health, including dietary habits (Dahl et al., 2014). However, personal finances are also an important factor in relation to dietary habits, as consumption of different product groups changes in line with prices (Mæland, 2019). Further, if the caretakers have low purchasing power, this will affect what food is bought and eaten, as the cost of food and affordability is important determinants (Raza et al., 2020). The parental economy was not examined in the present study, however, the majority of students replied that the cost of food was of the most importance when choosing what to eat (Appendix 4a). This can help to explain the high consumption of snacks, sugary beverages, and energy drinks, as these often are of low cost (Table 1, 2) (Monteiro et al., 2019).

Pricing of food is strongly linked to the personal food environment because people with lower incomes are most susceptible to price changes (Mæland, 2019). Further, studies have shown that there are price differences between a healthy and an unhealthy diet, and healthier eating habits are associated with higher costs (Darmon & Drewnowski, 2015; Rao et al., 2013). This can contribute to reducing the availability of healthy and nutritious food, particularly for people with low SES. A recently published article found that Norwegian families with a low income have to spend a larger proportion of their income on food compared to high-income families (Uldahl & Bere, 2023). Higher food prices will affect households with low income to a greater extent, which makes this group more exposed to price changes and could make it more challenging to access healthy food (Uldahl & Bere, 2023). This argues for free school meals to be introduced, as it will increase the availability of healthy food, especially for vulnerable groups who are most in need of such a measure. The school can help to strengthen favorable mealtime routines, but whether a school meal alone can change eating habits is rather uncertain, as eating habits are not influenced by finances alone. In addition, it is the

guardian who is responsible for purchasing food for the household, and parents become "gatekeepers" for the children's diet (Raza et al., 2020). If mainly foods of low nutritional value are bought, it is plausible that this is what the children eat because these are the types of food they have access to. A Norwegian study by Gebremariam et al. (2016) found that parental rules were associated with lower consumption of carbonated sugar-sweetened beverages and snacks, while perceived access at home was associated with increased consumption. Increased intake of fruit and vegetables was also associated with perceived access at home (Gebremariam et al., 2016). Thus, school meals as a measure alone will not necessarily help to change eating habits that have been learned at home, and what is learned is affected by socioeconomic conditions and practices among parents.

Eating habits are also influenced by marketing, and young people are particularly vulnerable. According to the Innocenti framework, regulating food labeling and marketing is essential for promoting healthy dietary habits (Raza et al., 2020). Additionally, advertisements have shown to affect dietary choices, attitudes towards foods, and taste preferences (Mc Carthy et al., 2022; Qutteina et al., 2019; Smith et al., 2019). In Norway, children under the age of 13 must be protected against the marketing of unhealthy food, while caution must be exercised for children between the ages of 13-16 (Matbransjens Faglige Utvalg, 2019). However, packaging, product placement, or sponsorships are not considered marketing by Norwegian regulations (Matbransjens Faglige Utvalg, 2019).

The food industry heavily promotes UPFs (Monteiro et al., 2019). These food items have a poor nutritional composition, are designed to be hyper-palatable, and are sold at a low cost which makes these foods easily financially accessible (Monteiro et al., 2019). Additionally, studies have shown that adolescents are high consumers of UPFs (Baraldi et al., 2018; Lauria et al., 2021; Machado et al., 2020; Neri et al., 2022). In the present study, 90% of the participants stated that taste was very important when making dietary choices (Appendix 4a). For the food being healthy and of low cost, 28% and 43% replied that these were important factors. This study showed that meal participation for lunch was high (74%)(Appendix 3). Additionally, there was a decrease in pupils eating fast food in schools with school meals. Nevertheless, the total intake of snacks increased, and the increase was greatest in the intervention group. One explanation for these findings may be that students ate the school meal but still bought snacks or food in nearby shops, during school hours, or on the way to school. As the taste and cost of food was of high importance, this indicates that adolescents

chose to eat unhealthy food items, including UPFs. In addition, two of the schools in the present study served breakfast, thus, it is unlikely that this would have affected the students´ lunchtime habits. Further, physical access to shops and kiosks near schools can also contribute to the fact that many pupils choose to buy food here in favor of bringing packed lunches or eating food offered by the school. Results from the study showed that the proportion of students eating food bought outside of the school 1-5 days per week increased at follow-up for school 1 serving breakfast, while a minimal decrease was observed for school 2, which also served breakfast (Appendix 4b). Further, school 3, serving both breakfast and lunch, showed a 5% decrease in students buying lunch.

A Norwegian study found a positive correlation between pupils who bought food in shops near the school and the consumption of snacks (Gebremariam et al., 2016). It was mainly food with low nutritional value and a high content of sugar and fat that was purchased (Gebremariam et al., 2016). This also corresponds to findings by Kolve et al. (2022), who observed that pupils who were not allowed to leave the school grounds, to a greater extent brought packed lunches compared to students who were allowed. In contrast, a reduction in the consumption of snacks was found, but also a reduction in pupils who purchased food at nearby shops when school meals were introduced (Kolve et al., 2022). It is important to point out that this study had a duration of 10 days, and dietary habits were assessed based on what the students ate the day before the survey was answered. This is not necessarily representative of the actual diet. Conversely, a systematic review found no associations between nearby shop purchases and food intake at school (Williams et al., 2014). However, over half of the included studies used BMI or fat mass as outcome measures. Although studies show different results when it comes to food intake and the environment around schools, monitoring and restricting marketing in schools have been suggested (Uldahl & Torheim, 2023; World Health Organization, 2021a). Further, it has been suggested that regulating food availability in schools by limiting unhealthy options and increasing access to healthy foods can have a positive impact on dietary habits (Dahl & Jensberg, 2011).

Other factors that are important in dietary choices are cultural and social related.
Young people are in a phase where they are becoming more independent. They are less bound to their parent's rules and become more autonomous, also when it comes to food choices. Nevertheless, adolescents are more exposed to other influences including advertising and food availability in stores or school canteens. Acceptance and desire for food products are linked to

sociocultural norms and are influenced by advertising and social media and people in the social circle, especially peers (Raza et al., 2020). Belonging is a basic human need, and fitting in with social norms is perhaps particularly important in adolescence. Further, the findings in this study show that a large proportion of pupils still skip breakfast, even when it was offered for free. Further, a high intake of snacks, soda, and energy drinks was observed, while consumption of fruit and vegetables was low. If skipping meals, shopping for food outside school, or eating certain foods is part of the food culture within a group, it can be a barrier to breaking out of this norm. This may be due to a wish to belong and not wanting to appear different, as sharing meals with others is a social activity (Story et al., 2002), also during school, where adolescents spend a large part of their time. Thus, eating also becomes an activity where one's food choices can be influenced by fitting in. In addition, taste is an important determinant of food choice, and it can be both biological and learned (Fox & Timmer, 2020). Based on this, it can be assumed that this is also the case during school hours, as students are likely to eat one or more meals during the school day. In addition, it is well documented that students at upper secondary schools eat snacks and energy-dense foods to a greater extent, while the consumption of fruit and vegetables is reduced. Similar trends were observed in the present study. This underpins the assumption that adolescents have a food culture where it is socially acceptable to eat unhealthy eating habits. There are few studies that have examined the extent to which friends and peers influence eating habits. In a systematic review by WHO (2021a), peer pressure, social norms and taste were three of several factors affecting eating habits among students. A review from 2020 concluded that peers have a negative influence on eating habits by increasing the consumption of foods with little nutritional value and high-energy density (Rageliene & Gronhoj, 2020). Nevertheless, according to Rageliene and Gronhoj (2020), this influence can also occur in a positive direction.

According to the Innocenti framework, adolescents' diets are strongly affected by several factors, including the food supply chain, marketing, economics, the environment, and social and cultural norms, which interfere crosswise. Taking measures at a systemic level can contribute to more people having physical and financial access to healthy food, which is especially important for children and adolescents. Implementing free school meals targets a vulnerable group at a public level, thus making healthy food more available, convenient, and accessible. However, other measures and conditions must also be considered for the school

food to reach its full potential. This involves other structural measures and the involvement of adolescents.

Today's regulatory scheme for marketing to adolescents has some limitations. The scheme is currently complaint-based and does not include marketing measures such as packaging or product placement, nor is supervision carried out (Meld. St. 15 (2022-2023)). Further, the regulations do not include adolescents aged 16-18, but the Norwegian Government will evaluate if this age group should be included (Meld. St. 15 (2022-2023)). A stricter set of regulations can help adolescents to be less influenced by the marketing of unhealthy food and potentially contribute to a healthier diet. Furthermore, price regulation can contribute to healthier eating habits. WHO (2013) suggests increasing the cost of unhealthy foods by taxation and offering subsidies for healthier foods. This will increase the financial availability of healthy foods, especially among low-income families. This can help increase the consumption of healthy food in households, which in turn can lead to healthier eating habits and a healthier food culture in the long term, as these measures are one of the most forceful measures in changing behavior (Nylenna, 2019). Further, price regulation could have the potential to make adolescents make healthier food choices when buying food during school hours. Lastly, taste and preferences should be considered when implementing school meals to increase meal participation. Thus, it could be beneficial to involve students in examining which foods are preferred and developing a meal model which is most suitable in relation to time schedule and/or meal preferences.

Methodological considerations

Method and study design

In the present study, data from a repetitive cross-sectional survey conducted in upper secondary schools in Viken in 2021 and 2022 was used. Cross-sectional studies are suitable for investigating characteristics such as disease prevalence or lifestyle behaviors in a population at a given time (Webb et al., 2017) and are therefore not suitable for drawing causal relationships. However, a cross-sectional study design makes it possible to collect data on a large scale and can thus provide valuable information about the population. Additionally, when the study is repeated, it can be used to collect information about any changes in the population. In the present study, both surveys matched, making it possible to estimate any changes in the population's dietary habits (UK Data Service, 2015). Additionally, a pilot project where free school meals were introduced at selected schools in Viken was initiated

between these surveys. This enabled an estimation of the interventions´ impact on students' dietary habits during school hours. A repeated cross-sectional design made it possible to collect a large amount of data. This study is important for expanding the knowledge of school dietary habits in Norway, as there is currently limited research on the topic.

Study sample

A limitation of the present study is that the schools selected for analysis were non-randomized. However, equal samples are a prerequisite for comparison, and randomizing the selection could have resulted in uneven conditions between intervention and control groups. Additionally, it was important that control schools were not participating in any other projects serving food. With non-randomization, this was avoided. A selection criterion was an equal distribution of responses from students with both vocational and general education. Further, schools included were evenly distributed across the county with both rural and urban localizations. Another criterion was high response rates in both surveys, and schools with responses of less than 100 were excluded. Further, as the implementation of school meals was done in various ways across the intervention schools, schools that carried out similar meal models were selected. Only one school included served lunch. This constituted a small part of the sample, and thus no conclusions can be drawn for the entire sample, which is considered a limitation. Nonetheless, all schools provided breakfast, which allowed for analyzing patterns in breakfast consumption among the total sample. Gender distribution was even in both samples, with the percentage of girls responding slightly higher. This corresponds to the gender distribution among the included schools (Utdanningsdirektoratet, 2023), indicating a representative sample. However, in the school year 2021-2022 the total proportion of male students in Viken County was higher (Utdanningsdirektoratet, 2023). The number of students who studied study preparatory subjects in Viken County this year was higher than for vocational subjects, according to figures from The Directorate of Education (2023). This also applied to the sample in this study, and the distribution was equal across groups.

The results in this study are based on two different samples, thus, changes in variables are at the population level. It is also important to point out that this study has included three out of twelve schools that have introduced free school meals in the county. How the measure has affected eating habits in the other schools is uncertain, and including these schools could have led to different results. However, excluded schools had a low response rate. Finally, the pilot

project had a duration of one year, including the project being interrupted by covid-19. It is important to underline that this is considered a short period of time when assessing the effect on dietary habits at the population level, which often takes time before a change is observed (Departementene, 2007).

Validity and reliability

High internal validity indicates that the results of a study are valid for the sample being studied (Pripp, 2018). Internal validity can be assessed based on conditions with sample selection, information bias, or the extent to which confounding factors have been taken into account (Webb et al., 2017). At baseline, 31% of participants took part in the study, while during the follow-up, the participation rate increased to 47% (Table 1). The low participation rate at baseline could be explained by the covid-19 pandemic. However, the participation rate in the control schools was substantially lower compared to the intervention schools. This could be a result of selection bias. The gender distribution or parental SES in the control and intervention group was not significantly different, but there was a larger proportion of girls in the total sample. As previously mentioned, this represents the gender distribution of the schools included in the study, and the internal validity is considered high.

Based on the sample size, distribution of parental SES, and study distribution, the results of this study may be transferred to other schools in Viken County. However, the gender distribution in the sample does not reflect the county. Additionally, lunch was served to one school only, but breakfast was served in all schools included in the study. Nevertheless, breakfast was served in different ways, and it is uncertain to what extent this may have affected the results at the individual schools. Further, examining the remaining schools that took part in the pilot project should be done before drawing any conclusions about generalizability. The data included in the present study is based on *The School Meal Survey*, which is considered to be of high quality as it is based on other national surveys (Nilssen, 2021). Further, the survey is developed by NIPH and has been adjusted to the population in Viken County (Nilssen, 2021) Therefore, the reliability of the survey is considered to be high.

Information bias

In the present study, students self-reported dietary intake in a food frequency questionnaire (FFQ). A well-known issue with self-report is misreporting of energy intake and other dietary

factors, causing errors. Under or overreporting is related to several characteristics such as age, gender, and weight (Castro-Quezada et al., 2015), which may cause differential misclassification. However, the present study includes two random samples where errors probably have affected the groups equally, causing a non-differential misclassification. Non-differential misclassification leads to underestimation of the true effect, and identifying associations is more challenging (Webb et al., 2017). Another challenge with using FFQs for dietary assessment is recall bias, as respondents are asked about their diet retrospectively (Naska et al., 2017). In the period of both surveys, the corona pandemic led to students being at home more often due to infection or quarantine. The alteration in the school schedule could have impacted the answers given, leading participants to provide inaccurate information unknowingly and subconsciously. However, students were asked to record food intake during a regular school week, and not consider periods with homeschooling and digital teaching, which was specified at the start of the survey and in the first question regarding breakfast frequency.

Operationalization

The dietary variables, as well as breakfast and lunch frequency, were dichotomized. By dichotomizing, the analyses and interpretation of the data are simplified, which is considered an advantage when presenting data (Altman & Royston, 2006). In the present study, the group of most interest was students reporting never eating breakfast or lunch. Thus, dichotomizing was considered optimal for this purpose. However, dichotomization leads to a loss of information and therefore reduces statistical power (Altman & Royston, 2006). In the present study, no significant results were observed, but a small difference was observed in the time x school status for breakfast frequency. This may be a result of dichotomization.

On the other hand, dichotomization made it possible to make a dietary sum score. To set limit values, the national dietary recommendations were used as guidelines. The score was developed to examine the respondent's diet in a more comprehensive way. Four food groups considered to be healthy were summed together: coarse grains, fruit, vegetables, and water. This was also done for unhealthy food items; fast-food, baked goods, chocolate and salty snacks, and sugar-sweetened beverages. Chocolate and salty snacks were merged into one variable to have a sum score with an equal number of variables for the healthy and unhealthy food groups. Additionally, it was desirable to include beverages in the sum score. Soda (diet and regular), energy drinks, and other sugary beverages were combined into one variable.

This was based on the dietary guidelines and the school meal guidelines stating that sugary and acidic beverages should not be offered in upper secondary schools (Helsedirektoratet, 2015).

The score ranged from -4 to 4 and consuming one food item from the unhealthy food group 1-5 days per week or several times per day gave a negative score of 1. Eating a healthy food item several times per week or five times per week gave a positive score of 1. A total score of 4 indicated a healthy diet, and a score of -4 indicated an unhealthy diet based on the dietary variables included in the sum score. A disadvantage of this score is that it does not give a nuanced picture of how healthy the respondents' diets were due to dichotomization. Eating fruit or vegetables 3-4 times per week is healthier than rarely or never eating these food items during a school week. Nevertheless, the study of interest was to examine respondents with a daily intake of unhealthy or healthy items rather than those who had an occasional intake. The stricter criteria for eating healthy made this possible. However, eating chocolate but not salty snacks gave the same negative score as consuming both items. The results could have been different if a more detailed diet rating system was used. The food score did not include all dietary variables examined in the survey, including fish, meat, milk, and juice, which is a limitation of the study. However, regarding the dietary variables, the aim of the study was to examine fruit and vegetable consumption and snacks, and this score included all related variables for this purpose.

Confounding

In the present study, gender and parental SES have been controlled for in analyses. Further, stratification on these variables was done. As discussed, there are several factors that affect eating habits that have not been controlled for, including taste preferences, social structures, and environmental factors. If these factors had been included, this could have influenced the results.

Statistical analysis

The main analysis in the present study was a multilevel linear mixed model with breakfast and lunch consumption and diet score (fruit, vegetable, grains, water, snacks, fast food, and soda) as dependent variables. Gender, SES (parental education), year (2021 and 2022), and groups

(intervention and control) were analyzed as fixed effects, and schools were nested as random coefficients.

Multiple regression on dependent dichotomous variables

In the present study, multiple regression analysis in terms of a mixed model was conducted to estimate possible associations between eating habits and SES, gender, and the introduction of school meals. Logistic regression is often used to analyze covariation when the dependent variable is dichotomous, and the independent variables are continuous. However, performing linear regression on dichotomous dependent variables makes little difference compared to logistic regression in significance tests, even when the assumption of homoscedasticity (a prerequisite for performing regression analysis) is absent (Hellevik, 2007). Further, as underlined by Hellevik (2007), linear regression is more applicable to examine causal relationships than log-linear measurements. This is because the sum of the components in the regression coefficient always corresponds to bivariate associations, also dichotomous variables that are interpreted causally (Hellevik, 2007). The interpretation of this type of analysis is also more intuitive and applicable compared to the parameter value for log-linear regression. Further, this method has also been used in a study with a similar design (Skreden et al., 2017).

Conclusion

The aim of this study was to examine whether introducing a free school meal would have an impact on students' dietary habits during school hours in Viken County. A free school meal in terms of breakfast showed no significant impact. However, a small positive change from baseline to follow-up was observed in the intervention group, indicating a possible impact. Further, when stratified on gender, findings were mixed. In the low parental SES group, breakfast skipping decreased in both groups. For lunch frequency and diet score, no significant results were observed.

Nevertheless, as empirical studies have shown, implementing school meals could lead to improved meal frequency. As a regular meal rhythm is positive for concentration and blood sugar regulation, it could lead to improved academic measures and cognitive function. Furthermore, school meals have the potential to improve dietary habits, including increased fruit and vegetable intake and reduced consumption of snacks. As dietary factors are an important determinant of health, improving diet among adolescents can reduce the

development of NCDs and obesity, which is a global health concern. Furthermore, school meals may contribute to a more favorable meal environment and make healthier foods more accessible and available for a large part of the population. However, this relies on students eating the meals served, and more studies in a context relevant to the Norwegian population are needed. Further, examining the reason why students don't make use of the school meal and the reasons why students purchase food outside school, even when free school meals are offered, is of particular interest. Including students in the development and organization of school meals and investigating barriers to meal participation could be an answer to this challenge. These barriers include taste preferences, allergies, and students' time schedules.

Further, dietary habits are affected by various factors at a structural level. Marketing of unhealthy foods has an impact on taste preferences, attitudes, and dietary choices. A stricter regulation could create a more favorable food environment, making adolescents less affected by advertisements on social media or in retail. Lastly, regulating food prices can help make unhealthy options less appealing and less financially available.

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Appendix

Appendix 1: The School Meal Survey (Translated from Norwegian)

Invitation to participate in research on school meals
Dear student

The school food survey is a survey about food and meals in secondary schools by the Norwegian Institute of Public Health.

The questions in the form concern food and meals, well-being, learning, concentration, and a bit about yourself and your family. When you answer the questions, base your answers during a normal school day (not home school or digital teaching). Your answers will be used for research on food and meals at school.

Your answers must be confidential, so do not answer the questions while others are watching.

Participation in the survey is voluntary and anonymous. If you answer, you have given your consent to participate. If you do not want to participate, do not answer the questions. If there is one or more questions you do not wish to answer, you can proceed to the next question. It takes about 10 minutes to complete the questionnaire. Remember to press "send" when you're done.

Read each question carefully, and answer as honestly as you can.
If you wish to answer in Bokmål, you can do so here.

Questions	**Answer options**
Are you a boy or a girl?	Girl Boy I do not want to answer
In which county is your school located?	[Drop down menu] Agder Innlandet

	Møre og Romsdal Nordland Oslo Rogaland Troms og Finnmark Trøndelag Vestfold og Telemark Vestland Viken
What school do you attend?	Answer options based on where county school is located
Which grade level are you in?	Upper secondary 1 Upper secondary 2 Upper secondary 3 Not applicable
Which study program are you attending?	Vocational course Preparatory course Not applicable
The following questions are about your family and your home. If you have several homes, you answer for the home you live in most or decide on one of the homes.	
Does your family have a car?	No Yes, one Yes, two or more
Do you have your own bedroom?	Yes No
How many times have you gone on holiday with your family in the past year?	Never once Once Twice More than twice
How many computers/tablets do they have in the family? School computers are not to be counted.	No One Two Three Four Five or more
How many books do you think you have at home? One meter of books corresponds approximately to 50 books	No books Less than 20 books 20-100 books 100-500 books 500-1000 books More than 1000 books
Do your parents/guardians have university or college education?	No, neither of them Yes, one of them Yes, both I do not know I do not want to answer
How well do you feel financially compared to most other people your age?	Just like most Better

	Worse
On a scale from 1 to 7, how important is it to you when you choose what food to eat? The scale goes from 1 (not important at all) to 7 (very important) That the food is healthy That the food is cheap That the food is sustainable That the food taste good That the food does not contain meat	 1 2 3 4 5 6 7
How often do you usually eat breakfast during the school week?	5 times 4 times 3 times 2 times 1 time I usually do not eat breakfat
During a normal school week, how often do you eat breakfast... "Normal school week" means the days you are at school during a week … at home? … at school? … somewhere else?	5 days a week 4 days a week 3 days a week 2 days a week 1 day a week Less often Never
Does your school offer free breakfast?	Yes, I have made use of the offer Yes, but I have not made use of the offer No I do not know
How often do you usually eat lunch during the school week?	5 times 4 times 3 times 2 times 1 time I usually do not eat lunch
For lunch during a normal school week, how often do you eat ..? Packed lunch/food that you have brought from home Free lunch at school Lunch bought at school Lunch that is bought outside the school's premises (shop, kiosk, fast food restaurant etc.)	 5 days a week 4 days a week 3 days a week 2 days a week 1 day a week Less often Never
During a normal school week, where do you usually eat lunch?	In the classroom In the school´s canteen

	Somewhere else in the school The school´s outdoor area Outside the school´s area I usually do not eat lunch
Does your school have a free lunch offer?	Yes, I have taken advantage of the offer Yes, but I did not take advantage of the offer No I do not know
How satisfied are you with the school's free lunch offer?	Very satisfied Satisfied Dissatisfied Very dissatisfied I do not know
During a typical school week, how often do you have lunch with other students?	5 days a week 4 days a week 3 days a week 2 days a week 1 day a week Less often Never
DURING SCHOOL TIME during a normal school week, how often did you eat any of the food items below?	
Coarse grain product (e.g. oatmeal, wholemeal bread, crispbread, etc.) Fruit and berries Vegetables and salads Fish (as part of a meal or as spread) Meat (as part of a meal or as spread) Fast food (kebab, burger, sausages, noodles, Rett i koppen (semi-finished product) etc. Buns, waffles or other sweet baked goods Potato crisps, salty snacks or similar Chocolate or other sweets	Several times a day 5 days a week 4 days a week 3 days a week 2 days a week 1 day a week Less than one time a week Never
DURING SCHOOL TIME during a normal school week, how often did you drink any of the beverages below?	
Water Milk Soda, juice, iced tea, iced coffee, chocolate milk or other beverages with sugar Sugar-free soda, juice or other sugar-free beverages Juice Energy drinks (Redbull, Battery etc.)	Several times a day 5 days a week 4 days a week 3 days a week 2 days a week 1 day a week Less than one time a week Never

During the time you are at school in a normal school week, how often does it happen that you throw away food?	Several times a day 5 days a week 4 days a week 3 days a week 2 days a week 1 day a week Less than one time a week Never
Does your school offer free fruit and/or vegetables?	Yes No I do not know
How well… …do you enjoy school? …do you enjoy the lunch break?	Very good Good A little Not in particular Not at all
Below are some claims about work tranquility and concentration. How much do you agree or disagree with the following: There is good work tranquility during school hours I find it easy to concentrate on schoolwork I think it is easy to follow the teaching at school	 Completely agree Agree Neither agree nor disagree Slightly disagree Completely disagree
If you have any other comments regarding the topic of school meals or on the form, you can write them here	

Appendix 2: Coding of variables and sum scores

Variables in bold refer to the variable´s name in the dataset.

Recoded variables

Variable	*Original coding*	*Recoding*
Parental SES	**Fas_utd** No, none of them - 1 Yes, the one - 2 Yes, both – 3 Don't know - 4 Do not want to answer - 5	**Fas_utd_2** No, none of them – 0 Yes, the one – 0 Yes, both – 1 Don't know - Missing Do not want to answer - Missing
Gender	**kjonn** Girl – 1 Boy – 2 Do not want to answer - 3	**kjonn_2_rekodet** Girl – 1 Boy – 2 Do not want to answer - missing
Study program	**Program** Vocational – 1 Study preparation – 2 Not applicable - 3	**Program_2_rekodet** Vocational – 1 Study preparation – 2 Not applicable - missing

Dichotomized variables

Variable	*Original coding*	Dichotomized variable
Breakfast frequency	**Frokost_frekv** 5 times - 1 4 times - 2 3 times - 3 2 times - 4 1 time - 5 I don't usually eat breakfast - 6	**Frokost_frekv_dikotom** 5, 4, 3, 2, 1 time – 1 I usually don't eat breakfast - 0
Does the school have a breakfast offer?	**B_grat_fru** Yes, I have used the offer - 1 Yes, but I have not used the offer - 2 No – 3 Don't know - 4	**B_grat_fru_rekodet** Yes, I have used the offer - 1 Yes, but I have not used the offer, no, I do not know - 0
Lunch frequency	**lunsj_frekv** 5 times – 1 4 times – 2 3 times – 3 2 times – 4 1 time – 5 I usually do not eat lunch - 6	**Lunsj_frekv_dikotom** 5,4,3,2,1 time – 1 I usually do not eat lunch - 0
Frequency of eating lunch bought outside school grounds (retail, kiosk, fast	**Lunsj_utenf** 5 times per week - 1 4 times per week - 2 3 times per week - 3	**Lunsj_utenf_dikotom** 5,4,3,2,1 time – 1 Less than once a week, never - 7

food restaurant etc.)	2 times per week - 4 1 time per week - 5 Less than once a week - 6 Never - 7	
Does the school have a lunch offer?	**B_lunsj_grat** Yes, I have used the offer - 1 Yes, but I have not used the offer - 2 No - 3 I do not know - 4	**B_lunsj_grat_rekodet 2** Yes, I have used the offer - 1 Yes, but I have not used the offer, No, I do not know - 0
Fruit intake	**frukt** Several times per day – 1 5 days a week – 2 4 days a week – 3 3 days a week – 4 2 days a week – 5 1 day a week – 6 Less than once a week - 7 Never - 8	**Frukt_2** Several times per day, 5 times a week – 1 4,3,2,1 days a week, less than once a week, never – 0
Vegetable and salad intake	**gront** Several times per day – 1 5 days a week – 2 4 days a week – 3 3 days a week – 4 2 days a week – 5 1 day a week – 6 Less than once a week - 7 Never - 8	**Gront_2** Several times per day, 5 times a week – 1 4,3,2,1 days a week, less than once a week, never – 0
Intake of coarse grains	**Korn** Several times per day – 1 5 days a week – 2 4 days a week – 3 3 days a week – 4 2 days a week – 5 1 day a week – 6 Less than once a week - 7 Never - 8	**Korn_2** Several times per day, 5 times a week – 1 4,3,2,1 days a week, less than once a week, never – 0
Fast food intake	**hurtig** Several times per day – 1 5 days a week – 2 4 days a week – 3 3 days a week – 4 2 days a week – 5 1 day a week – 6 Less than once a week - 7 Never - 8	**Hurtig_2** Several times per day, 5,4,3,2,1 days a week – 1 Less than once a week, never - 0
Baked goods	**bakevarer**	**Bakervarer_2**

	Several times per day – 1 5 days a week – 2 4 days a week – 3 3 days a week – 4 2 days a week – 5 1 day a week – 6 Less than once a week - 7 Never - 8	Several times per day, 5,4,3,2,1 days a week – 1 Less than once a week, never - 0
Chips	**Chips** Several times per day – 1 5 days a week – 2 4 days a week – 3 3 days a week – 4 2 days a week – 5 1 day a week – 6 Less than once a week - 7 Never - 8	**Chips_2** Several times per day, 5,4,3,2,1 days a week – 1 Less than once a week, never - 0
Chocolate	**sjokolade** Several times per day – 1 5 days a week – 2 4 days a week – 3 3 days a week – 4 2 days a week – 5 1 day a week – 6 Less than once a week - 7 Never - 8	**Sjokolade_2** Several times per day, 5,4,3,2,1 days a week – 1 Less than once a week, never - 0
Soda and sugary beverages (lemonade, iced tea and coffee, chocolate milk and other beverages with sugar)	**brus** Several times per day – 1 5 days a week – 2 4 days a week – 3 3 days a week – 4 2 days a week – 5 1 day a week – 6 Less than once a week - 7 Never - 8	**Brus_2** Several times per day, 5,4,3,2,1 days a week – 1 Less than once a week, never - 0
Soda (diet)	**Sukkerfribrus** Several times per day – 1 5 days a week – 2 4 days a week – 3 3 days a week – 4 2 days a week – 5 1 day a week – 6 Less than once a week - 7	**Sukkerfri_brus_2** Several times per day, 5,4,3,2,1 days a week – 1 Less than once a week, never - 0

	Never – 8	
Energy drinks	**Energidrikk** Several times per day – 1 5 days a week – 2 4 days a week – 3 3 days a week – 4 2 days a week – 5 1 day a week – 6 Less than once a week - 7 Never - 8	**Energidrikk_2** Several times per day, 5,4,3,2,1 days a week – 1 Less than once a week, never - 0
Water	**Vann** Several times per day – 1 5 days a week – 2 4 days a week – 3 3 days a week – 4 2 days a week – 5 1 day a week – 6 Less than once a week - 7 Never - 8	**Vann_2** Several times per day, 5, days a week – 1 4,3,2,1 days a week, less than once a week, never - 0

Diet sum score

	Variables	Score
Coding - healthy food items	Grains [Korn_2] Fruit [Frukt_2] Vegatables [Gront_2] Water [Vann_2]	Consumption several times per day, 5 times a week gives a score of 1. Consumption less than this gives a score of 0 Total max score = 4
Coding – healthy food items	Fast food [Hurtigmat_2] Baked goods [Bakevarer_2] Chocolate or chips [Sjokolade_chips_2] [1] Soda, sugary beverages and energy drinks [Usunn_drikke_2][2]	Consumption 1-5 days per week or several times per day gives a score of -1 Consumption less than this gives a score of 0 Total max score = -4

[1] The variables for chocolate and chips [sjokolade_2, chips_2] were merged and assigned a new column (Sjokolade_chips_2) to get the same number of variables in the diet score and recoded as follows: 0=0, 1=1, 2=1.

[2] The variables for soda, sugary beverages, and energy drinks [brus_2, sukkerfri_brus_2 and energidrikk_2] was merged and assigned a new column (usunn_drikke_2) and recoded as follows: 0=0, 1=1, 2=1, 3=1.

Appendix 3: Number of respondents in intervention schools reporting to have used or not used the school meal offer (%)

School	**Breakfast**		**Lunch n**	
	Made use of the offer	Did not make use the offer[1]	Made use of the offer	Did not make use the offer[1]
1	18	82		
2	55	45		
3	52	48	74	26

[1] Based on the answers: «I do not know" or "no".

Appendix 4a: Distribution of price, taste and healthiness as important factors when choosing food (%)

	Very important 6-7	**Not important (1-2)**
The food is healthy	28	9
The food is of low cost	43	10
The food taste good	90	1

Based on a scale from 1-7 where 1 = not important at all, 7 = very important.

Appendix 4b: Distribution of students eating lunch bought outside from the schools´ area 1-5d/w (%)

	Intervention			**Control**	
School number	**Baseline**	**Follow-up**	**School number*** **	**Baseline**	**Follow-up**
1*	36	50	A	42	50
2*	71	69	B	40	47
3**	65	60	C	49	54

*Serving breakfast **Serving breakfast and lunch ***The letters A, B and C show changes in trends for each of the three control schools but are not described in further detail.

Appendix 5: Regression analysis for school 3 serving breakfast and lunch. The table shows changes in breakfast and lunch frequency, and diet sum score from 2021 – 2022 by gender, SES, and school status (intervention/control). Compared to all control schools.

	Estimate	SE	p	Lower 95% CI	Upper 95% CI
Breakfast					
Gender [girls]	-0.024	0.01	0.0119*	-0.043	-0.005
SES [low]	-0.036	0.009	<0.0001*	-0.055	-0.018
School status [control]	-0.006	0.013	0.6487	-0.02	0.033
Time period [2021]	-0.013	0.013	0.3221	-0.039	0.013
Time period [2021]*control schools	0.006	0.013	0.6594	-0.02	0.032
Lunch					
Gender [girls]	-0.004	0.005	0.3895	-0.013	0.005
SES [low]	-0.005	0.004	0.2390	-0.014	0.003
School status [control]	-0.0027	0.006	0.6751	-0.01	0.015
Time period [2021]	-0.008	0.006	0.2013	-0.02	0.004
Time period [2021]*control schools	0.0008	0.006	0.9007	-0.012	0.013
Diet sum score					
Gender [girls]	0.082	0.04	0.0409*	0.003	0.161
SES [low]	-0.18	0.04	<0.0001*	-0.26	-0.1
School status [control]	0.031	0.056	0.0201*	0.021	0.242
Time period [2021]	0.002	0.056	0.9780	-0.11	0.111
Time period*control schools	0.036	0.056	0.5209	-0.07	0.145

Breakfast: 5d/w. Lunch: 5d/w. Diet sum score is based on intake of healthy (fruit, vegetables, coarse grain products, water several times a day, 5 d/w) and unhealthy food items (fast food, snacks, chocolate, and soda, several times a day, 1-5 d/w). *Significant change, $p < 0.05$

Appendix 6: Change in proportion of students reporting consumption of beverages during school hours between 2021 and 2022 by gender and parental SES (%)

	Intervention			Control		
	2021 (95% CI)	2022 (95% CI)	Change 21-22	2021 (95% CI)	2022 (95% CI)	Change 21-22
Soda, sugary beverages, energy drinks[1,2]						
Girls	75 (70 – 78)	74 (69 – 78)	-1	68 (64 – 72)	70 (67 – 73)	2
Boys	76 (72 – 81)	80 (75 – 84)	4	75 (70 – 80)	75 (71 – 79)	0
High SES	75 (70 – 79)	73 (68 – 78)	-2	69 (64 – 73)	73 (69 – 76)	4
Low SES	76 (71 – 80)	78 (73 – 83)	2	75 (70 – 80)	73 (68 – 77)	-2
Water[1]						
Girls	80 (76 – 83)	77 (72 – 81)	-3	76 (72 – 79)	78 (75 – 81)	2
Boys	73 (69 – 78)	71 (66 – 76)	-2	73 (68 – 78)	79 (75 – 82)	6
High SES	78 (73 – 82)	76 (71 – 80)	-2	73 (69 – 77)	79 (76 – 82)	6
Low SES	76 (71 – 80)	72 (66 – 77)	-4	77 (72 – 82)	78 (74 – 81)	2

[1]Several times per day, 1-5 days per week. [2] Includes lemonade, iced tea/coffee, chocolate milk, and other beverages with sugar. CI: confidence intervals. SES: socioeconomic status

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