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Dietary habits in Swedish children, adolescents and their parents and corresponding greenhouse gas emissions

Investigating associations between sociodemographic and energy-balance factors and climate impact of the diet

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Abstract

Introduction: Food production is both responsible for and at great risk of being negatively affected by climate change. Changes in food consumption could play an important role in reducing these negative effects. Investigating how individual characteristics associates to greenhouse gas emissions (GHGE) from the diet could guide which groups to target in future interventions. Children and adolescents have thus far been underrepresented in research within this field.

Aim: To investigate the associations between sociodemographic and energy-balance factors and the levels of GHGE as well as food patterns (ratio of animal to plant based foods) among the families participating in the Swedish I.Family study cohort. An additional aim was to investigate parent-child similarities in diet and diet-related GHGE.

Methods: Using an exploratory cross-sectional design, simple- and multiple linear regression was performed to investigate associations between sociodemographic and energy-balance factors with GHGE and the ratio of animal to plant-based foods. Correlations between children/adolescents and their parents were investigated through Spearman's correlation.

Results: GHGE was positively associated with age, male sex, and migration status. No associations were observed for other sociodemographic or energy-balance factors. Food patterns showed positive associations with male sex among children and parents but not among adolescents. There were parent-child similarities in GHGE among children, no similarities were seen for food patterns.

Conclusion: Age and sex are associated with GHGE from an early age, with males having a higher GHGE and increases with age for children and adolescents. Interventions to decrease GHGE should be directed through parents and schools with focus on males.

Key words: *climate change, diet, greenhouse gas emissions, sustainability, dietary intake*

1 Introduction

Food production is responsible for around one quarter of global greenhouse gas emissions (GHGE) and one of the largest contributors to climate- and environmental change [1, 2]. These emissions are expected to increase in the years to come due to a growing population, increased incomes and changed consumption patterns [3, 4]. Paradoxically our food production is not only one of the largest contributors to climate change but also at great risk when facing these changes since they are threatening to disrupt the food supply chain leading to an increased global food insecurity. Some changes are already visible today; changed precipitation patterns, more extreme weather events and higher temperatures, all factors that have an effect on food production and public health. In order to mitigate the worst-case scenario and maintain the economic- and public health improvements seen the past 50 years, the emissions from food production need to diminish drastically. Changing food patterns at an individual level has the potential of playing an important role in this shift [4, 5]. Understanding underlying patterns of who consumes an unsustainable diet would help identifying target groups for future interventions.

According to consumer behavior theories, what people consume depends on a large range of factors*; individual differences* such as resources (money, knowledge, time), attitudes, values and lifestyle, *environmental factors* such as culture, socio-economic position, influence from people around you (family, people of position) and *psychological factors* such as what needs and desires you have [6]. This indicates that there are factors connected to individual characteristics and social surroundings that determines what we consume, and this is also true when it comes to consumption of food. Investigating these characteristics could therefore give an insight in who eats a sustainable, or unsustainable, diet.

Estimating greenhouse gas emissions from the diet is one way to evaluate the sustainability profile, with higher GHGE standing for a more unsustainable diet. Research within the area of sustainable food consumption indicates that a diet high in GHGE, could be associated with higher socioeconomic status [7, 8]. However, there are also studies that did not find any association at all [9, 10]. Results concerning fixed factors such as age and sex show consistent results regarding sex but are inconclusive when it comes to age; some studies indicate that young people tend to have higher climate score from their diets [11, 12] while others contradict this result showing that GHGE increased with age [9, 13]. Males seem to have a higher climate score from the diet compared to females and not only due to a higher food intake [9, 12, 13]. Some studies indicate that energy-balance factors (factors representing energy expenditure and storage) such as BMI and physical activity could have an association with GHGE [7, 10, 11]. Only one study was found investigating individual characteristics and corresponding GHGE from diets among children and adolescents aged 7-18 in the Netherlands [10]. To our knowledge, no study has examined this question in parents and children from the same household.

This study aims to build on the knowledge around what sociodemographic and energy-balance factors could be associated with levels of greenhouse gas emissions in a Swedish setting with a special focus on children and adolescents, since these age groups have so far been insufficiently investigated globally, and we are not aware of any such studies in a Swedish context.

2 Aim

The aim of this study is to investigate the climate impact, expressed as greenhouse gas emissions, of the dietary habits of the families from the Swedish I.Family Study cohort, with a special focus on children and adolescents. The main aim is to investigate associations between sociodemographic and energy-balance factors and levels of GHGE. Secondary aims is to investigate the association between age and sex with a related dietary pattern (ratio of animal to plant based foods) and the correlations between children, adolescents and their parents.

2.1 Research questions

Research questions to help reach the aims of this study are the following:

1. *Is there an association between sociodemographic- and energy-balance factors (age, sex, education, income, migration status, BMI, sports club participation and screen time) and levels of greenhouse gas emissions from the diet?*
2. *Is there an association between age, sex and a diet pattern based on the ratio of animal to plant-based foods?*
3. *Is there a correlation between children and adolescents' greenhouse gas emissions from the diet or food patterns with that of their parent?*

3 Material and Methods

3.1 Study design

This exploratory study employs a cross-sectional design to investigate associations between sociodemographic and energy-balance factors and the greenhouse gas emissions from their diets. A secondary data analysis is based primarily on dietary intake data from the Swedish I.Family study cohort, and other information collected at the same time. In addition, climate data (GHGE) corresponding to the dietary information was provided by the Research Institutes of Sweden (RISE) and the study is therefore a collaboration between the University of Gothenburg and RISE.

3.2 Population and data collection

The I.Family study is part of a larger European longitudinal cohort named "*Identification and prevention of dietary- and lifestyle- induced health effects in children and infants*" (IDEFICS). The overarching aim of the larger study was to investigate how factors such as food choices, behavioral- and socioeconomic factors relate to non-communicable diseases (NCD's) with special focus on how to prevent overweight and obesity among children. In each country community-based samples were recruited, where two or more communities were chosen to represent the sociodemographic- and infrastructure of the region. Each child, of age 2-10 years, enrolled in kindergarten or primary schools within the communities was eligible to take part in the study and it was in these settings the parents of the child were approached and invited to participate. Data collected included social and behavioral factors, individual characteristics and medical parameters [14].

Data was collected at three time points across eight countries; at baseline 2007-2008 (T0), after 2 years (T1) and in 2013-2014 (T3). At the first follow up, T1, new participants were recruited in the same community or through classmates of the participants of T0. In 2013-2014 a third examination wave, T3, was conducted including IDEFICS children and other family members (I.Family). In this study, siblings aged 2-15 years, and parents of the original participating children (index children) were recruited together with the index children. In total 7105 of the index children (from T0 and T1) along with 2512 newly recruited siblings were included together with at least one of their parents. All together 6167 families were included [14].

In this study only data from the Swedish I.Family data is used, which is collected from three municipalities in the west part of the country, namely; Partille, Alingsås and Mölndal [15]. In total 1383 individuals were included in our study. From a total of 547 families, 493 participants were children (<12years), 282 were adolescents (12-18 years) and 608 were adults (>18 years).

3.2.1 Food Frequency Questionnaire

A food frequency questionnaire (FFQ) was used to evaluate food intake among children, adolescents and parents of the I.Family, as part of the "Eating Habits Questionnaire" (EHQ), answering how often they consumed 60 food items. An example of one page from the FFQ is shown in Appendix 1. Participants answered the question "In the last month, how many times did you eat or drink the following food items?" by ticking in options best matching their intake ranging from 'Never/less than once a week' up to '4 or more times per day'. The adolescents and the parents filled in the document themselves while the children's FFQ was filled in by the parent, answering about food intake under their control. The questionnaires to the different age groups were of similar structure and used the same food categories with the exception of alcohol not being included in the children's version. The EHQ was developed in English and translated into 11 languages and back translated to validate translation. Reproducibility of the questionnaire and validation of its components has been conducted in the eight survey countries participating in the IDEFICS and I.Family studies [16, 17].

The answers from the FFQ were converted into weekly frequencies, with a range from 0-30 times per week. Age- and sex specific portion sizes were used to estimate the amount of food intake (kg per week) for each food item. The portion sizes are derived from a validated FFQ used in previous studies in a Swedish setting (personal communication A.Wolk) [18, 19]. For food categories where no data on portion sizes were available, standard portion sizes from the Swedish Food Agency database were [20]. To transform the adult portion sizes into portion sizes for children and adolescents, data from the Nordic Nutrition Recommendations on energy requirements was used to calculate a ratio between children, adolescents and adult requirements which was then used to transform the weekly food intakes into age-specific estimates [21].

3.2.2 RISE Climate data

Climate impacts were associated to each food item in the FFQ according to the RISE Food Climate Database version 1.5 (2018). The database contains climate data based on studies of life cycle assessment (LCA) from Sweden and abroad. Climate data comes from the 2018 database version which includes the climate impacts based on research up until this year and representing the most updated and trustworthy studies of this time point.

The unit used to express climate impact is carbon dioxide equivalents (CO_2e) per kilo food produced, with higher CO_2e having a higher climate impact. The data used in this study includes the product's climate impact from all the steps in production until the product leaves the producer or industry (cradle to gate). It does not include the transport to the consumers, with the exception of products transported to Sweden, or impacts with home preparation [22]. The foods included to represent each FFQ item were selected to best represent the Swedish consumption and their climate impact refers to the ready to eat food, such as cooked and not raw meat. Since the FFQ grouped different food products together under one category, such as meat and fish, climate numbers from different food items were weighted according to consumption statistics from the Swedish Board of Agriculture and RISE (seafood) to give one number for the whole category [23, 24]. For the food categories where no consumption statistics were available an average of the included products were calculated. Appendix 2 presents items that are included in each food group. Furthermore, RISE climate data was compared to average climate impacts from a European study to confirm their validity and highlight eventual differences, see Appendix 3.

3.2.3 Food categories

The food items in our study was divided into 19 food groups and 3 overarching food categories; Animal-based, Plant-based and Discretionary in order to group foods with similar origin and climate impact, see Appendix 4. The Animal- and plant-based food categories represent products that normally contribute to a basic diet. The discretionary food category contained products that were either difficult to divide into animal- or plant-based foods, such as combined foods which could be either, or could be considered of more discretionary character, such as sodas and snacks. Water was excluded and sweetened coffee and tea was grouped together with unsweetened coffee and tea; hence 57 food items were included in our analysis.

3.3 Ethical considerations

All materials included within the I.Family cohort study has been collaboratively produced across the participating countries, translated into local language and approved by local ethics committees, in Sweden by the Regional Ethics Committee of the University of Gothenburg. Written and oral consent was gathered for each study participant and through the parent of a participating child, and they were informed of their freedom to consent to the whole or parts of the study and that the data would only be used for informed purposes. The children had to orally consent to each examination. The data was anonymized by separating identification numbers from personal identification and was only accessible to authorized personnel [25-27].

For this particular study only anonymized secondary data was used, therefore no further permission was required than the obtained permission from the Steering Committee of the I.Family study cohort.

3.4 Variables

Independent variables included in this study represent variables that previously have been shown to have an association with levels of GHGE, or where the results are so far inconclusive, and therefore interesting to investigate again and in a younger population [7, 9-13]. No previous studies were found investigating associations between migration status or screen time and levels of GHGE. However, studies and reports have indicated these variables being connected to differing food patterns, which could result in varying climate scores [28-30]. Hence, these were considered interesting to investigate in relation to GHGE.

3.4.1 Outcome variables

To calculate a climate score for each food item the intake (kg food/week) was multiplied with the GHGE-estimate (kg CO_2e/ kg food). The GHGE score from each food item was then summed up to give a climate score for the whole diet (kg CO_2e/week) and was used as the primary outcome. The total kilo intake of each food category was created by summing up the intake (kg/week) for each food item within the category. The ratio of animal to plant based non-discretionary foods was used as an alternative outcome.

3.4.2 Sociodemographic variables

Variables included to capture sociodemographic factors were: parental income, parental education and migration status of parents. Migration status of parents was included as an alternative social indicator which indicated if both parents of the child had Swedish background or not. The income variable consisted originally of five categories, the lowest defined as belonging to the lowest quartile of the Swedish average net equivalence income and the highest belonging to the highest quartile [31]. These were combined into three income variables: 'low-medium income', 'medium-high income' and 'high income'. Under 5% of the study population belonged to the lowest income levels. Education level represents the highest level of educational attainment within the household classified according to the International Standard Classification of Education (ISCED) [32]. Since no participants reported to belong to the 'low level education' the variable was dichotomized into medium- and high education level, which represent either only 'gymnasium level' or 'university level or higher' in a Swedish context. Migration status was dichotomized into; 'both parents non-migrant' or 'one or both parents' migrant'.

3.4.3 Energy-balance factors

BMI, sports club participation and screen time are all variables related to energy-balance and was therefore considered relevant to investigate together. For children BMI z-scores according to Cole was used which compares BMI values with reference standards for children/adolescents within the same age and sex [33]. Sports club participation represented how many hours and minutes/week the individual participated in sports club activities. All missing values from this variable were replaced with 0, assuming that those who did not fill in anything did not participate in sports club activities. After the main analysis based on this assumption a sensitivity analysis was performed removing all missing values from sports club participation which yielded similar results. The variable reflecting screen time was created by taking the maximum value of two variables measuring TV, computer and internet use. Screen time was only recorded for children and adolescents therefore no tests were run with this variable for parents.

3.5 Sample selection

The participants with more than 50% missing values from the FFQ were excluded from our study. After exclusion the remaining missing values ware treated as 'not consumed' and given a value of 0, based on the same procedure as previous studies [34-36]. This resulted in excluding a total of 77 participants: 34 children, 31 adolescents and 12 parents. One extreme implausible observation was excluded in the adolescent group to avoid interference with the results. In total 78 people were excluded from the study cohort leaving a number of 1383 in the analysis.

3.6 Method of analyses

All statistical analyses were performed using the IBM Statistical Package for the Social Sciences (SPSS) Version 26 and were stratified by age group (children 2-12 years, adolescents 12-18 years and parents >18 years). The distribution of each outcome (kg co2e/week and animal/plant ratio) was checked and log transformed due to positively skewed curves in order to obtain a normal distribution of the residuals in linear regression models. To account for multiple testing a stricter p-value of 0.01 was set to avoid obtaining significant results by chance (inflated Type 1 errors) [37, 38]. This significance level was used for all tests. Results were reported in terms of the estimated beta-coefficient (ß), which gives the mean change in log GHGE (or in log animal-plant ratio) if the predicting variable is increased by 1 unit, together with a 99% confidence interval (99% CI). The beta-coefficients are shown in Tables 2-5. The estimated beta-coefficient ß may also be used to calculate the relative change in percent in the original outcome (i.e. GHGE or animal-plant ratio) variable per 1-unit change of the predictor, as (exp(ß) -1) x 100%. The percentage change was reported in the text for selected associations. In the subsample, where total energy intake was available, it was significantly correlated with total food intake in kg/week (TFI), see Appendix 5. Since a larger food intake in itself can yield a higher GHGE from the diet, i.e. due to higher energy requirement in growing children or adults, adjustments were made for total food intake to ensure that potential associations were not only due to a higher food intake. The main analyses adjusted for total food intake, mainly because it had no missing values compared to energy intake.

3.6.1 Associations with greenhouse gas emissions

To investigate associations between sociodemographic and energy-balance factors in relation to GHGE (kg CO_2e/week), based on food intake from the FFQs, simple and multiple linear regression analysis were performed. The independent variables were grouped into different categories and analysed separately with GHGE as following:

- **Fixed sociodemographic factors;** *age and sex*
- **Sociodemographic factors;** *education, income and migration status*
- **Energy-balance factors;** *BMI, sports club participation and screen time*

In all categories each independent variable was first analyzed separately with GHGE (Model 1) then mutually adjusted for all independent variables in the category (Model 2) and finally further adjusted for total food intake (Model 3). Sociodemographic and energy-balance factors were adjusted for age and sex in each model.

3.6.2 Associations with dietary patterns

The same models as described above were also used when investigating the association between age, sex and dietary pattern (ratio of animal to plant based foods) in simple and multiple linear regression. First age and sex separately with GHGE (Model 1), then mutually adjusted (Model 2) and finally by, in addition, adjusting for total food intake (Model 3).

3.6.3 Correlation between diets of children, adolescents and their parents

To explore how the above-mentioned outcomes (GHGE and ratio of animal to plant based foods) were correlated between (i) children and parents, and (ii) adolescents and parents, Spearman's correlation was calculated. Separate tests were run to analyze associations with same sex and opposite sex parent. Correlations were stratified for children and adolescents.

4 Results

4.1 Descriptive characteristics

Characteristics of the study population are shown in Table 1. Among the children (n= 493), 52.5% were boys and 47.5% were girls. Adolescents (n=282) had a similar sex distribution, 48.9% boys and 51.1% girls, while parents (n= 608) were dominated by mothers (66%). The mean age was 9 years and 13 years among children and adolescents, and among parents 45 years and 43 years of age for fathers and mothers respectively. The sample consisted of a relatively well-educated group, since no family was classified by having low parental education. There was a relatively even spread in income, but the majority of the sample belonged to either 'low-middle' or 'high' income. The majority of the parents did not have a migrant background, meaning they were Swedish born. The mean BMI-score among children and adolescents were within the range for normal weight (between -1 and +1 SD) [14] but among parents the mean BMI was above the threshold for overweight among fathers (BMI>25). The most active group was the adolescents who had a mean sports club participation of around 3.8 hours/week. This group also had the highest reported amount of screen time, with adolescent boys showing the highest mean of 29 hours/week, however the standard deviation was 14 hours meaning there were large differences within the group. The food groups that contributed the most to the GHGE score was meat and meat products for all age groups. This was followed by milk and yoghurt, see Figure 1 and 2.

4.2 Associations with greenhouse gas emissions

4.2.1 Fixed factors; age and sex

Sex was significantly associated with GHGE in all age groups, with higher climate scores for males compared to females (p<0.001), see Table 2. This association persisted after adjusting for age and for total food intake, although attenuating the effect, indicating that part of the association between sex and GHGE were explained by e.g. the lower total food intake in women compared to men. After adjusting for total food intake girls had a -10(-16, -4)% lower climate score compared to boys among children and -15(-25, -4)% lower climate score among adolescents and mothers had a -23(-28, -18)% lower climate score compared to fathers.

Among children, age was significantly associated with GHGE in all models (p=0.000), with an increased climate impact among those with higher age. For each year increase in age, children had a 3(1, 5)% higher climate score after adjusting for total food intake. For adolescents age was significantly associated with GHGE in model 1 (p=0.000) and model 2 (p=0.000) but only marginally so after adjusting for total food intake (p=0.01). This means that for adolescents the association between age and GHGE could be explained by a higher food intake with higher age. For parents, age was not significantly associated with GHGE in any of the models (p>0.01).

4.2.2 Sociodemographic factors; education, income and migration status

Migration status and GHGE were significantly associated among children both in the simple regression model (p=0.001) and the multivariable model (p=0.001), see Table 3, showing that children with non-Swedish parents had a higher climate score. This association disappeared after adjusting for total food intake (p=0.48), meaning that it was a higher amount of food that accounted for the difference. Neither education nor income was significant in any age group (p>0.01) or in any of the models meaning these did not have any association with GHGE in our study population.

4.2.3 Energy- balance factors; BMI, sports club and screen time

When investigating associations between BMI, sports club participation and screen time separately with GHGE no significant association were found between any of the variables with GHGE (p>0.01), see Table 4. This result persisted in all models. Thus, energy balance factors were not associated with GHGE food pattern or in the total diet, i.e. with or without adjustment for total food intake.

4.3 Associations with dietary patterns

Sex was significantly associated with animal/plant ratio in the non-discretionary part of the diet among children (p=0.000) and parents (p=0.000), with males having a higher ratio compared to females, independent of total food intake, see Table 5. Among children, girls had a -28(-36, -18)% lower ratio compared to boys, and mothers had a -22(-34, -8)% lower ratio compared to fathers.

Sex was not significantly associated with ratio of animal/plant-based foods among adolescents ($p>0.01$). Age was not significantly associated with animal/plant ratio among children and adolescents ($p>0.01$) but the association was significant for parents ($p=0.004$). This association persisted after adjusting for sex ($p=0.000$) and total intake ($p=0.000$) meaning the association was independent of total food intake. For every year of age increase the animal/plant ratio decreased with -2(-4, -1)% among parents.

4.4 Correlations between children, adolescents and parents

Spearman's correlation to investigate correlation between children's and adolescents' climate score from diet with their parents showed a significant, positive correlation between children of both sexes and their mothers and fathers ($p=0.000$), except for boys and their fathers whose scores were not correlated ($p=0.12$), see Table 6. Adolescent boys' scores were significantly positively correlated with those of their fathers ($p=0.007$) but not with their mothers ($p=0.015$). Adolescent girls' scores were not correlated with either those of either parent ($p>0.01$). For the animal/plant ratio food pattern, no significant correlation was found between children or adolescents and either of their parents ($p>0.01$), see Table 6.

5 Discussion

This study showed positive associations between age, male sex and migrant status and levels of GHGE among the families participating in the I.Family study. No association was found between other socioeconomic- or energy-balance factors (education, income, BMI, sports club participation or screen time) and levels of GHGE. Age and sex showed a significant association with dietary patterns (ratio of animal to plant based foods) among children and parents, and there was an association between children's and parents' GHGE, with the exception of boys.

No correlation was found between parents and their children when it comes to the animal/plant food ratio pattern.

5.1 Fixed factors

5.1.1 Age

Previous studies have found associations between high age and high GHGE [9, 13] as well as the reversing trend [7, 11] in an adult population. This study provides insight of the association between age and GHGE in a younger population than previously explored. In our study parents did not show any significant association with GHGE, but associations were found among children and adolescents. Children had an increased climate impact with every year increase in age, independent of amount of food, see Table 2. This does not seem to be due to a higher animal to plant ratio since age was not significant in this age group when analyzing food patterns, see Table 5. In the latest national food survey among children sugar-added products were the largest contributor to the daily energy intake [29]. Therefore, it is not impossible that the food category containing these products (discretionary food category in our study) plays a role in the increase of the climate score with age. However, analysis on food item level would be needed in order to understand the underlying patterns for the increase of GHGE with age in our population.

Adolescents also had an increased climate impact from the diet with age, but this seem to be related to an increase in amount of food intake since the association did not persist after adjusting for total food intake, see Table 2, and no association was found between age and animal to plant ratio in this age group, see Table 5.

Age was not associated with GHGE for parents, as mentioned before, which contradicts previous findings [11, 13]. However, after adjusting for total food intake the results were changed towards almost being significant (p=0.02), see Table 2. When looking at food patterns age was significantly associated with animal to plant ratio, with a lower ratio with older age, see Table 5, indicating that GHGE from food patterns might still have some association with age among parents in our study population.

5.1.2 Sex

Previous studies have found that males tend to have higher climate scores from their diet compared to women both due to higher energy intake but also by differing food patterns with higher meat intake among men [9, 12, 13]. This association corresponded with the finding from this study and also show a similar trend among children and adolescents. The boys and fathers had a higher mean GHGE score compared to girls and mothers in all age groups. Males had a higher climate score due to amount of intake, but also due to different food patterns in all age groups. Among children and parent's, sex was also significantly associated with animal to plant ratio, see Table 5, which indicates that the higher climate score among males in these age groups should be accounted by a higher intake of animal-based products.

There was no association between animal to plant ratio and sex for adolescents, meaning that the difference seen in GHGE between sex in this age group is not due to differing intakes from the animal- and plant-based food category. There is a chance that no association was found due to a smaller study population in this group or it indicates that the higher climate score among males in this age group was accounted by differing food choices within the animal food category, with girls tending to choose animal-based products with lower climate scores. Again, further investigations on food item level would be needed to know what accounts for the difference in sex seen in the adolescent group.

5.2 Sociodemographic- and energy-balance factors

5.2.1 Migration status

In our study there was a significant association between migration status and GHGE from the diet, with a higher score for children of parents with migrant background. However, this association did not persist after adjusting for total food intake, meaning that in our sample none of the age groups were associated with differing GHGE from the diet due to different food patterns but rather a higher food intake. In a Swedish food survey, children of parents with non-Swedish background had differing food patterns compared to those of Swedish origin [29]. Our results on the animal/plant ratio pattern did not seem to correspond to this finding. However, the majority of our study population had parents of Swedish background, meaning that the sample size may have been too small to detect differences between families with immigrant and native-born parents. Moreover, this non-Swedish group was very heterogeneous with even smaller numbers from specific countries of origin.

5.2.2 Other sociodemographic and energy-balance factors

Previous studies have found associations between SES-factors and GHGE, with significantly higher GHGE from those with higher socioeconomic status among adults [7, 8, 11, 12]. In our study neither education nor income showed any significant association with GHGE in any of the age groups. When it comes to education, the only previous study among children and adolescents did not find any association between level of education (based on parental education) and GHGE either. The default association in our study could therefore either be due to small differences in SES in our population, with i.e. none belonging to lowest educational level, or that the education factor is not as associated with GHGE in a younger population. The true difference might lie between high and low education level, a difference we were not able to investigate in our sample. A Finnish study found the strong associations between income and GHGE, with higher climate scores among those with higher income [8]. However, their study population consisted only of single or couple households without children, and divided the income into five categories, compared to three in our study which could be an explanation of the differing results. More studies are needed before establishing the role of SES when in regard to GHGE from the diet among children and adolescents. It could be that free school meals in Sweden help leveling some of the socioeconomic differences seen in an adult population.

Previous studies have found associations between BMI and climate scores, with higher BMI among those with higher GHGE, as well as between physical activity and levels of GHGE [7, 10, 11]. No such associations were found in this study. However, further studies are needed before the associations between these factors with GHGE from the diet can be ruled out. The insignificant results could be due to a too low power in the subsample used in this study.

5.3 Implications

5.3.1 Targeting children

Since children had the clearest associations with both age and sex, with increasing climate impact from the diet with growing age and a higher impact from boys compared to girls this group should be targeted in future interventions. Childhood is considered a critical period where food preferences are developed and the food habits learned early in life usually persist throughout life [39, 40]. Therefore, this age group is especially important to reach early on in life. Arenas to intervene include within the family context and schools, both through shaping of preferences and affecting what food is offered, since children are dependent on others for their food intake.

What food children prefer to eat can already be influenced by the mother's food habits during pregnancy or during breastfeeding since the flavors can transcend to the child through the mother. Other factors that influence children's preferences include the social surrounding, such as what type of foods they are familiar with from home and influence from peers [40, 41]. The fact that the children in our study are influenced by their parent's food habits is supported by the significant correlation between children and parental GHGE (with the exception of boys to their father), see Figure 5. However, no significant correlation was found between children and their parents when looking at ratio of animal-plant based foods, indicating that what contributes to the climate score might differ between children and parents. There is therefore a need to further investigate on a food item level to know what foods contributes the most, and how it differs between parents and children.

Schools are also an important arena to target in order to shape children's preferences in a positive way, since school meals can contribute to a large part of the food intake during school days. This stresses the importance of school cafeterias providing a climate friendly meal and being a positive role model. For some children this might be the only place they come across sustainable food. Setting up boundaries of maximum GHGE from school meals, similar to regulations of nutritional quality, would simplify meal planning and steer school meals towards more climate friendly alternatives. However, since school meals were not captured in the children FFQ, the contribution of these meals were not evaluated in this study which could be important to measure in future studies.

5.3.2 Reducing animal-based products

Reducing the intake of animal-based foods has been repeatedly expressed as a necessity to achieve a reduction of GHGE from the diet, with the reduction of meat playing the largest role [2, 42-44]. In our study, the food groups contributing most to the GHGE was meat, followed by dairy products, see Figure 1 and 2, which indicates that meat seem to have the largest effect on climate scores in our study as well. Röös et al [45] explored the effects of replacing 50% of the Swedish meat consumptions with domestically grown legumes and found that the climatic impact from the diet would reduce by 20% and still keep the diet within the recommended levels of macro- and micronutrients. Limiting the amount of red and processed meat would also have positive co-benefits on health. According to the World Cancer Research Fund, limiting the intake of red and processed meat to 350-500 gram per weak would decrease the risk of cancer, high blood pressure and cardiovascular disease. [46]

Research has shown that the willingness of reducing the meat intake is low, with meat standing for social and cultural values. Males have been shown to tend to have a higher reluctance to decrease meat intake compared to females [47, 48]. This could be connected to the finding that males tend to have a higher climate scores in this and previous studies [9, 12, 13]. A higher meat intake among males have been suggested to be connected to gender structures, with meat being perceived as more masculine and plant-based diets more feminine [49-51]. A study from Finland, investigating awareness of climate change and behavioral changes, showed that in females with high concern about climate change was more strongly associated with dietary changes then in males [52]. Thus, there seem to be a need to understand underlying mechanisms and how to best motivate people to make changes in order to be successful and this might prove to be a greater challenge than just informing people of the right choices. Based on our study, investigating how to target males from an early age with such an intervention would be of interest.

5.4 Strengths and limitations

Strengths of this study include using the climate scores from RISE. These numbers correspond to the best national data available at this time and numbers was chosen to best match Swedish consumption patterns, and therefore our study populations [53]. These estimates were also shown to highly correlate to European average scores, see Appendix 3, but gave lower numbers due to differing system boundaries.

Using greenhouse gas emission as an indicator of sustainability when evaluating the impact from diets can be seen as a limitation. The climate numbers included in this study only look at the impact on the climate and does not include other potential negative, or positive, effects on the environment such as land and water use, acidification, eutrophication or biodiversity. However, using GHGE has so far been the most commonly used. There are contradictory research concerning if high GHGE also correspond with other negative environmental impacts. Studies have both argued that they do [54], and that they don't [55].

Limitations concerning gathering data through FFQ include; self-reporting bias, meaning you record i.e. more favorable food intake, recall bias, meaning limitations in remembering what has been consumed, and the failure to capture a whole diet since you only report intake of the food items you are asked about [56]. However, there is no perfect way to measure dietary intake. A previous study also found that FFQs compared to 24h recalls underestimated the climate scores, which means that the GHGE from the diets might be higher in reality than reported here [57]. The FFQ used in this study was developed to capture healthy or unhealthy dietary patterns and put a larger emphasis on preparation method. To better capture the environmental impact from diets it would be beneficial to gather more detailed information within the food groups, instead of grouping larger food categories together, which could i.e. be achieved through using 24-hour dietary recall in future studies. Another limitation connected to the FFQ in our study is that it does not cover school meals in children, since parents were instructed to only report intake under their control.

Because of logistic necessities to draw local rather than national representative sample when recruiting to the IDEFICS and I.Family study, there are limitations in how generalizable the results are to a larger Swedish population, especially when it comes to the effect of socioeconomic variables [14]. Specifically, the less socioeconomically advantaged portions of the Swedish population are under-represented in this sample. There might also be a too low power in the subsample to detect some associations, which could partly explain insignificant results. Another limitation connected to this study is the cross-sectional design, since no causal relationship can be drawn. However, the study shows potential patterns to guide future research or interventions.

6 Conclusions

This study shows that associations between sex and levels GHGE are visible from an early age, with males having a higher climate score from their diet compared to females. This difference could be due to a higher intake of animal-based foods (compared to plant-based foods) among boys and fathers in the children and parent group. Children and adolescents were also shown to have an increasing climate score with age, even if this seem be due to a higher food intake with age among adolescents. No clear associations were found between socioeconomic or energy-balance factors and levels of GHGE which was in contrast to some previous studies.

Important implications based on this study are to target children from early age, through family- and school interventions, since the associations between age, sex and GHGE are visible from an early age and the climate score of children seem to be correlated with that of their parents. Further investigations are needed to understand what underlying food patterns account for the levels of GHGE and how it might differ between children and adults. Understanding these patterns and how to best intervene could play an important role in reducing the GHGE from the food sector and securing healthy lives for present and future generations [58].

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9 Tables and figures

Table 1. Characteristics of the study sample by age group and sex

	CHILDREN		ADOLESCENTS		ADULTS	
	Males	Females	Males	Females	Males	Females
Total number	259	234	138	144	207	401
Sex (%)	52.5	47.5	48.9	51.1	34	66
Age						
Mean (sd)	9.35 (1.79)	9.29 (1.81)	13.36 (0.93)	13.42 (0.87)	45.57 (5.8)	43.04 (4.85)
Median	9.7	9.4	13.3	13.4	44.9	43
Education N(%)						
Numbers missing	2	5	1	1	6	10
Low	-	-	-	-	-	-
Middle	58 (22.6)	43 (18.8)	35 (25.5)	35 (24.5)	46 (22.9)	94 (24)
High	199 (77.4)	186 (81.2)	102 (74.5)	108 (75.5)	155 (77.1)	297 (76)
Income N(%)						
Numbers missing	8	5	13	6	8	14
Low-medium	86 (34.3)	80 (34.9)	37 (29.6)	54 (39.1)	65 (32.7)	142 (36.7)
Medium-high	66 (26.3)	64 (27.9)	39 (31.2)	40 (29)	54 (27.1)	111 (28.7)
High	99 (39.4)	85 (37.1)	49 (39.2)	44 (31.9)	80 (40.2)	134 (34.6)
Migration status N(%)[1]						
Numbers missing	4	4	1	1	5	11
Both parents non migrant	211 (82.7)	203 (88.3)	116 (84.7)	118 (82.5)	173 (85.6)	335 (85.9)
One or both parents migrant	44 (17.3)	27 (11.7)	21 (15.3)	25 (17.5)	29 (14.4)	55 (14.1)
BMI[2]						
Mean (sd)	0.16 (0.98)	0.16 (0.97)	0.24 (0.98)	0.13 (0.87)	25.63 (3.32)	24.35 (3.93)
Median	0.02	0.09	0.21	0.13	24.95	23.5
Sports club participation (h/week)						
Mean (sd)	2.9 (2.2)	2.21 (1.97)	3.82 (3.13)	3.67 (3.17)	1.76 (2.12)	1.55 (1.74)
Median	2.75	2	4	3.58	1	1
Screen time (h/week)[3]						
Numbers missing	3	5	4	6	-	-
Mean (sd)	18.97 (8.7)	15.44 (8.03)	29.24 (13.89)	22.45 (12.1)	-	-
Median	17.75	14.25	26.13	20.5	-	-
GHGE score[4]						
Mean (sd)	17.38 (6.3)	14.48 (5.4)	24 (10.9)	17.95 (8.1)	27.25 (10.7)	18.78 (7.03)
Median	16.59	13.67	21.84	16.12	25.16	17.53

[1] Migration status defined as non-Swedish background
[2] BMI z-scores used for children and adolescents
[3] Parents did not report screen time
[4] Kg co2e/week

FIGURE 1. Mean GHGE/week (kg co2e/week) for each food group among females

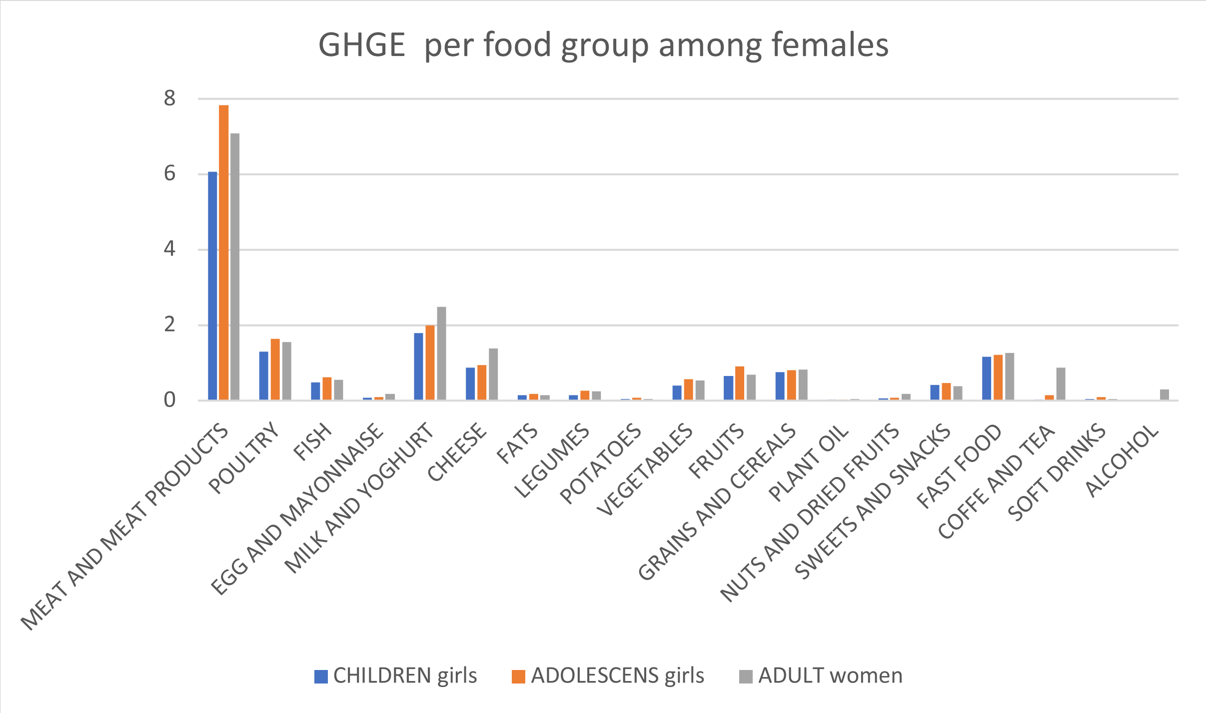

FIGURE 2. Mean GHGE/week (kg co2e/week) for each food group among males

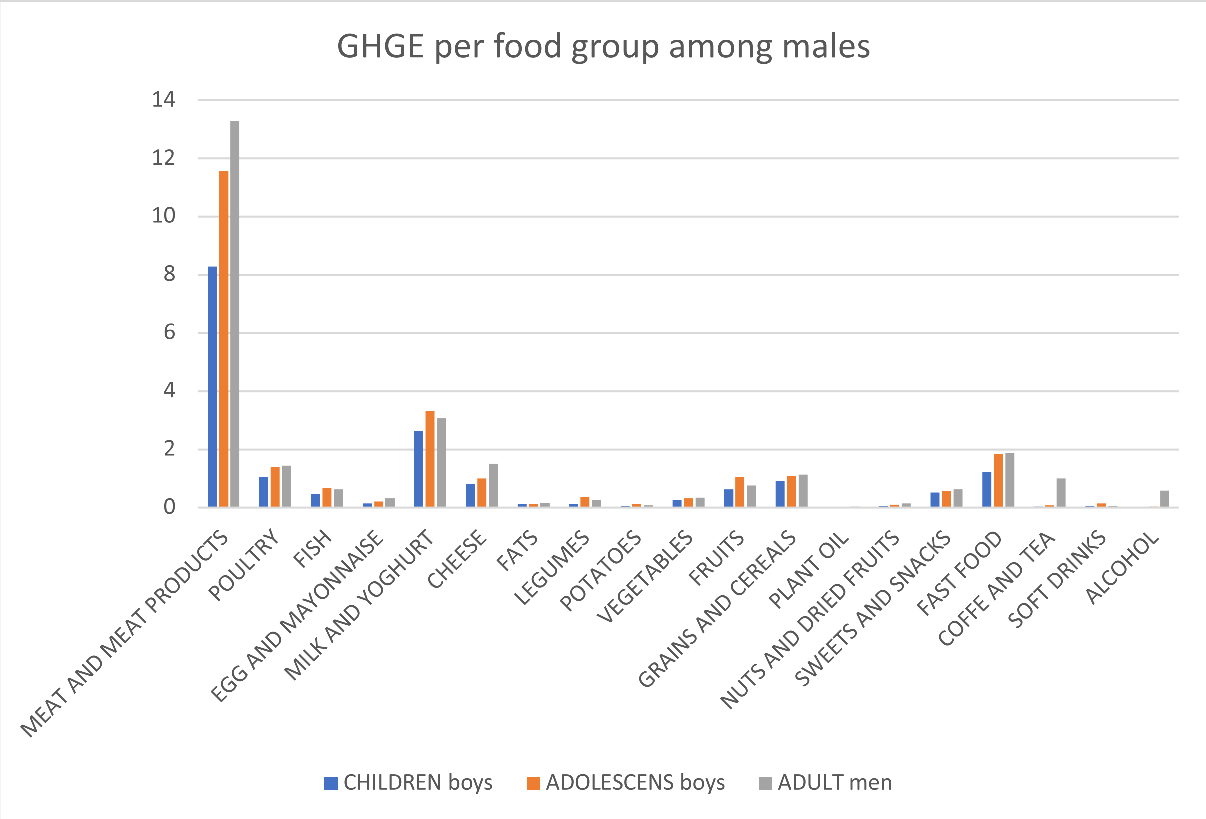

Table 2. Associations between log GHGE (kg CO_2e/week) and age, sex, and total food intake[1]

	CHILDREN			ADOLESCENTS			ADULTS		
	ß	P	99 % CI	ß	P	99% CI	ß	P	99% CI
Model 1: Simple models									
Age	0.08	***0.000***	0.57, 0.10	0.12	***0.000***	0.04, 0.20	0.004	*0.14*	-0.003, 0.01
Sex	-0.18	***0.000***	-0.27, -0.09	-0.28	***0.000***	-0.43, -0.14	-0.36	***0.000***	-0.44, -0.29
Model 2: Age and sex mutually adjusted									
Age	0.08	***0.000***	0.06, 0.10	0.12	***0.000***	0.04, 0.20	-0.003	*0.26*	-0.01, 0.004
Sex	-0.18	***0.000***	-0.26, -0.1	-0.29	***0.000***	-0.43, -0.15	-0.37	***0.000***	-0.45, -0.29
Model 3: Further adjusted for total food intake **(TFI)**									
Age	0.03	***0.000***	0.01, 0.05	0.07	*0.01*	0.00, 0.14	-0.005	*0.02*	-0.01, 0.001
Sex	-0.11	***0.000***	-0.17, -0.04	-0.16	***0.001***	-0.29, -0.04	-0.26	***0.000***	-0.33, -0.2
TFI	0.08	*0.000*	0.07, 0.09	0.05	*0.000*	0.04, 0.06	0.04	*0.000*	0.04, 0.05

1 Total kilo of food intake/week

Table 3. Associations between log GHGE (kg CO_2e/week) and education, income and migration status

	CHILDREN			ADOLESCENTS			ADULTS		
	ß	P	99 % CI	ß	P	99% CI	ß	P	99% CI
Model 1: Simple models adjusted for age and sex									
High education[1]	0.04	*0.34*	-0.06, 0.14	0.02	*0.79*	-0.15, 0.19	0.08	*0.02*	-0.01, 0.17
Income[2]									
medium-high	-0.07	*0.10*	-0.17, 0.04	0.1	*0.18*	-0.09, 0.29	0.03	*0.34*	-0.06, 0.13
high	-0.004	*0.92*	-0.1, 0.09	0.15	*0.03*	-0.03, 0.34	0.05	*0.15*	-0.04, 0.14
Migration status	0.15	***0.001***	0.04, 0.26	0.03	*0.71*	-0.17, 0.22	-0.03	0.53	-0.13, 0.08
Model 2: All SES factors mutually adjusted and adjusted for age and sex									
High education[1]	0.04	*0.31*	-0.06, 0.14	0.02	*0.74*	-0.21, 0.16	0.07	*0.04*	-0.02, 0.17
Income[2]									
medium-high	-0.05	*0.26*	-0.15, 0.06	0.10	*0.16*	-0.09, 0.29	0.04	*0.33*	-0.06, 0.13
high	0.01	*0.9*	-0.09, 0.10	0.17	*0.02*	-0.02, 0.36	0.04	*0.24*	-0.05, 0.13
Migration status	0.15	***0.001***	0.04, 0.27	0.05	*0.56*	-0.16, 0.25	-0.03	0.48	-0.14, 0.08
Model 3: All SES factors mutually adjusted, adjusted for age and sex and further adjusted for total food intake (TFI)									
High education[1]	0.36	*0.23*	-0.04, 0.11	-0.02	*0.74*	-0.17, 0.13	0.01	*0.77*	-0.07, 0.08
Income[2]									
medium-high	-0.02	*0.46*	-0.1, 0.06	0.06	*0.34*	-0.1, 0.22	-0.001	*0.96*	-0.08, 0.08
high	0.02	*0.43*	-0.05, 0.1	0.12	*0.04*	-0.03, 0.28	0.04	*0.15*	-0.03, 0.12
Migration status	0.03	*0.48*	-0.07, 0.11	0.06	*0.39*	-0.11, 0.22	-0.05	*0.18*	-0.14, 0.04
TFI	0.09	*0.000*	0.08, 0.1	0.05	*0.000*	0.04, 0.06	0.04	*0.000*	0.04, 0.05

[1] Reference medium education
[2] Reference low-medium income

Table 4. Associations between log GHGE (kg CO_2e/week) and BMI, sports club participation and screen time

	CHILDREN			ADOLESCENTS			ADULTS		
	ß	P	99 % CI	ß	P	99% CI	ß	P	99% CI
Model 1: Separate models adjusted for age and sex									
BMI	0.03	*0.06*	-0.01, 0.07	-0.03	*0.37*	-0.11, 0.05	0.002	*0.58*	-0.01, 0.01
Sports club participation	-0.01	*0.43*	-0.03, 0.02	0.02	*0.04*	-0.004, 0.04	0.014	*0.06*	-0.01, 0.03
Screen time[1]	0.004	*0.05*	-0.001, 0.01	0.001	*0.72*	-0.01, 0.01	-	-	-
Model 2: All energy balance factors mutually adjusted and adjusted for age and sex									
BMI	0.03	*0.07*	-0.013, 0.07	-0.02	*0.58*	-0.1, 0.06	0.003	*0.46*	-0.01, 0.01
Sports club participation	-0.01	*0.49*	-0.03, 0.02	0.02	*0.02*	-0.003, 0.04	0.02	*0.04*	-0.004, 0.04
Screen time[1]	0.003	*0.09*	-0.002, 0.01	0.002	*0.45*	-0.004, 0.01	-	-	-
Model 3: All energy balance factors mutually adjusted, adjusted for age and sex and further adjusted for total food intake (TFI)									
BMI	0.01	*0.47*	-0.02, 0.04	-0.003	*0.92*	-0.07, 0.06	0.002	*0.59*	-0.01, 0.01
Sports club participation	-0.01	*0.21*	-0.02, 0.01	0.02	*0.04*	-0.004, 0.04	0.01	*0.08*	-0.01, 0.03
Screen time[1]	0.002	*0.17*	-0.002, 0.01	0.001	*0.75*	-0.004, 0.01	-	-	-
TFI	0.08	*0.000*	0.07, 0.09	0.04	*0.000*	0.03, 0.06	0.04	*0.000*	0.04, 0.05

[1] No screen time recorded for parents

Table 5. Associations between log animal/plant ratio[1] and age and sex

	CHILDREN			ADOLESCENTS			ADULTS		
	ß	P	99 % CI	ß	P	99% CI	ß	P	99% CI
Model 1: Separate models for age and sex									
Age	0.02	*0.13*	-0.02, 0.06	0.02	*0.66*	-0.11, 0.16	-0.02	***0.004***	-0.03, -0.002
Sex	-0.32	***0.000***	-0.45, -0.2	-0.2	*0.03*	-0.44, 0.04	-0.19	***0.003***	-0.35, -0.03
Model 2: Age and sex mutually adjusted									
Age	0.02	*0.15*	-0.02, 0.05	0.03	*0.61*	-0.11, 0.16	-0.02	***0.000***	-0.04, -0.06
Sex	-0.32	***0.000***	-0.44, -0.2	-0.20	*0.03*	-0.44, 0.03	-0.24	***0.000***	-0.41, -0.08
Model 3: Further adjusted for total food intake									
Age	0.02	*0.11*	-0.01, 0.06	0.03	*0.63*	-0.11, 0.16	-0.02	***0.000***	-0.04, -0.01
Sex	-0.33	***0.000***	-0.45, -0.2	-0.2	*0.03*	-0.44, 0.04	-0.25	***0.000***	-0.42, -0.08
TFI	-0.01	*0.51*	-0.03, 0.02	0.001	*0.93*	-0.02, 0.02	-0.003	*0.59*	-0.02, 0.013

[1] log of kg animal-based foods per week/kg plant-based foods per week

Table 6. Correlation between children / adolescents and parental total GHGE (kg co2e/week) and ratio animal/plant-based foods

	CHILDREN				ADOLESCENTS			
	Boys-fathers	Boys-mothers	Girls-mothers	Girls-fathers	Boys-fathers	Boys-mothers	Girls-mothers	Girls-fathers
Total number	119	195	196	89	57	97	98	53
Greenhouse Gas Emissions								
Spearman correlation coefficient	0.144	0.459	0.351	0.395	0.352	0.245	0.020	0.139
P-value	0.12	***0.000***	***0.000***	***0.000***	***0.007***	*0.015*	0.84	0.320
Ratio animal/plant								
Spearman correlation coefficient	0.161	0.051	0.152	0.049	0.058	0.040	-0.146	0.160
P-value	0.080	0.480	0.034	0.648	0.667	0.700	0.152	0.253

10 Appendices

Appendix 1. Example page from the FFQ used in the IDEFICS/I.Family cohort study

5 **In the last month, how many times did your child eat or drink the following food items? Please indicate only foods and drinks you know about, i.e. what your child ate in your presence.**
Please tick one answer per line.

In the last month...	Never/ less than once a week	1-3 times a week	4-6 times a week	1 time per day	2 times per day	3 times per day	4 or more times per day
Vegetables							
Legumes (e.g. beans, lentils, chickpeas <local examples>)	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Potatoes (cooked, not fried)	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Fried potatoes, potato croquettes	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Other cooked vegetables (<local examples>)	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Raw vegetables (mixed salad, carrot, fennel, cucumber, lettuce, tomato, <local examples> etc.)	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Fresh fruits							
Fresh fruits (also as freshly squeezed juice) **without** added sugar	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Fresh fruits (also as freshly squeezed juice) **with** added sugar	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Drinks							
Water (tap water, carbonated water, plain water)	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Fruit juices (100% fruit), packaged (orange juice, apple juice, <local examples> etc.)	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Carbonated sugar sweetened drinks (e.g. coca cola, fanta, non-alcoholic beer, <local examples> etc.)	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Diet carbonated drinks, (e.g. diet cola, <local examples> etc.)	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Sugar sweetened drinks, not carbonated (e.g. bottled ice tea, syrup-based drinks and similar, fruit juices with less than 100% fruit, sports drinks, non-alcoholic wine, <local examples> etc.)	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7

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Appendix 2. List of food items included in each food group.

ANIMAL-BASED

MEAT AND MEAT PRODUCTS

Cold cuts and preserved, ready to cook meat products
- Sausage pork/beef
- Ham
- Liver pâté

Meat, boiled, grilled, oven baked, without coating, not fried
- Cooked beef
- Cooked pork
- Sausage

Fried meat
- Fried beef
- Fried pork
- Minced meat pork/beef
- Sausage

POULTRY

Poultry, boiled, grilled, oven baked, without coating, not fried
- Cooked poultry

Fried poultry
- Fried poultry

FISH

Canned fish
- Tuna in water/oil
- Mackerel in tomato sauce
- Herring

Fish, boiled, grilled, oven baked, raw, not fried without coating
- Salmon
- Cod
- Saithe
- Alaska pollock

Fish fried and/or coated
- Fried fish fingers
- Fried salmon
- Fried herring
- Fried mackerel

EGG AND MAYONNAISE

Fried or scrambled eggs
- Fried egg

Boiled or poached eggs
- Boiled egg

Mayonnaise and mayonnaise-based products
- Mayonnaise

MILK AND YOGHURT

Plain, unsweetened milk
- Whole milk 3%
- Semi-skimmed milk 1,5%
- Skimmed milk 0,1%

Sweetened and/or flavored milk
- Milk chocolate drink

Plain unsweetened yoghurt or kefir
- Whole fat yoghurt 3%
- Semi-skimmed yoghurt 1,5%
- Skimmed yoghurt 0,5%

Sweet, flavored yoghurt and fermented milk beverages
- Fruit yoghurt whole fat 3%
- Fruit yoghurt semi-skimmed 1,5%
- Fruit yoghurt skimmed 0,5%

CHEESE

Sliced cheese
- Sliced cheese 31% fat
- Sliced cheese 17% fat

Spreadable cheese
- Cream cheese 33% fat
- Cream cheese 16% fat

Grated cheese
- Cheese 31% fat

FATS

Reduced-fat products on bread
- Bregott semi-skimmed
- Lätta Margarine

Butter, margarine on bread
- Butter 80% fat
- Bregott 80% fat
- Margarine 70% fat

PLANT- BASED

LEGUMES

Legumes

- Green peas
- Boiled green lentils
- Boiled white beans
- Boiled brown beans
- Conserved beans

Tofu, tempeh, quorn, soy meat, soymilk

- Minced soy
- Soya sausage
- Tofu
- Soymilk

POTATOES

Potatoes (cooked, not fried)

- Potatoes

Fried potatoes, potato croquettes

- Fried potatoes

VEGETABLES

Other cooked vegetables

- Cauliflower
- Broccoli
- Beetroot

Raw vegetables

- Sallad
- Cale
- Tomato
- Paprika
- Spinach
- Carrot
- Cucumber

FRUITS

Fresh fruit (also as squeezed juice) without added sugars

- Orange
- Citrus fruit
- Orange juice
- Apple
- Pear
- Banana
- Other fruits

Fresh fruits with added sugars

- Same as above

Fresh juices (100% fruit), packaged

- Orange juice

GRAINS AND CEREALS

Porridge, oatmeal, gruel, unsweetened cereals, plain muesli

- Oat porridge
- Rice porridge
- Muesli

White bread, white roll, white crispbread

- Wheat bread
- White crispbread

Whole meal bread, dark roll, dark crispbread

- Rye bread

Pasta, noodles, rice and other cereals, white, refined

- Pasta
- Rice

Whole meal pasta, noodles, brown rice and other cereals, unrefined

- Fiber pasta
- Oats
- Wheat pollard

Dish of milled cereal

- Couscous
- Bulgur

Sweetened or sugar added breakfast cereals and sweetened crisp muesli

- Refined cereals, i.e. corn flakes

PLANT BASED OILS

Plant oil for cooking and/or salads

- Olive oil

NUTS AND DRIED FRUIT

Nuts and seeds

- Almonds
- Cashew
- Hazelnuts
- Peanuts
- Pistachio
- Walnut
- Flaxseeds
- Sunflower seeds

Dried fruits

- Dried fruit

DISCRETIONARY

SWEETS AND SNACKS

Jam, honey
- Jam from berries
- Apple sauce
- Raspberry jam
- Honey

Ketchup
- Ketchup

Chocolate or nut-based spread
- Nutella
- Peanut butter

Snacks like chocolate, candy bars
- Dark chocolate
- Milk chocolate
- Chocolate crackers

Snacks like candies, loose candies, marshmallow
- Candy

Snacks like biscuit, packaged cakes or pastries and puddings
- Cinnamon bun
- Sugary cake
- Danish pastry/croissant
- Sweet crackers
- Crackers i.e. Digestive
- Cake
- Fruit pie

Ice cream, milk or fruit-based bars
- Vanilla ice-cream

Snacks like crisps, corn crisps, popcorn, etc.
- Crisps

FAST FOOD AND SNACKS

Pizza as a main dish
- Pizza

Not homemade burger, hot dog, kebab, wrap, falafel, sandwiches
- Kebab meat
- Hamburger
- Sausage
- White bread
- Filled baguette
- Falafel

Snacks like savory pastries and fritters
- Pancakes
- Meat pie

COFFEE AND TEA

Coffee
- Filtered coffee

Tea
- Tea

SOFT DRINKS

Carbonated sugar sweetened drinks
- Soda

Diet carbonated drinks
- Soda

Sugar sweetened drinks, not carbonated
- Fruit drink

Artificially sweetened drinks, not carbonated
- Fruit drink

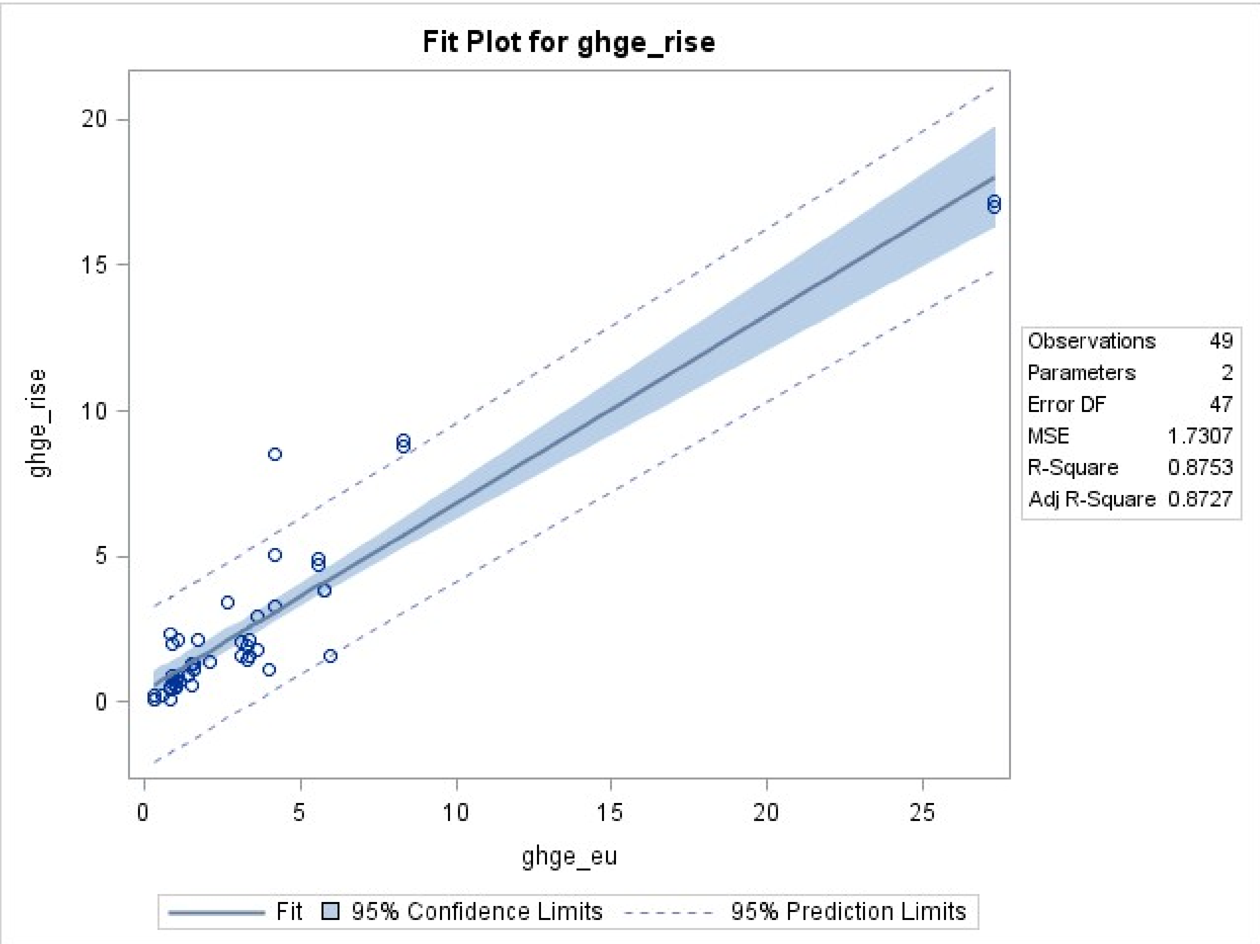
ALCOHOL

Alcoholic beverages
- Beer
- Read wine
- Wine
- Liquor

Appendix 3. Food group-based correlation between Swedish (RISE) and European climate estimates (based on Hartikainen et al. *Summary of the chosen methodologies and practices to produce GHGE-estimates for an average European diet.* 2016).

The climate estimates from RISE and from Hartikainen et al. uses different system boundaries, meaning that they stop measuring the climate impact at different points. RISE measure the climate impact from cradle to gate, meaning until the product leaves the industry while Hartikainen et al. measure the climate impact until consumption which explains the higher climate estimates from the European study. Another methodological difference that might explain diverging results include the fact that Hartikainen climate estimates are chosen to match a European average diet while the climate estimates from RISE are chosen to best match Swedish consumption in this study.

Even though the methodological differences make the climate estimates difficult to compare directly the results from Spearman's correlation still showed a good correlation between the Swedish and European numbers, indicating that the national Swedish scores are generalizable and comparable to other European populations. Spearman correlation coefficient = 0.86 ($p < .0001$).



Appendix 4. Food categories

ANIMAL-BASED	PLANT-BASED	DISCRETIONARY
Meat and meat products	**Legumes**	**Sweets and snacks**
Cold cuts and preserved meat products	Legumes	Jam, honey
Meat, boiled, grilled (beef, pork)	Tofu, tempeh, quorn, soy meat, soymilk	Ketchup
Fried meat (beef, pork)	**Potatoes**	Chocolate-or nut-based spread
Poultry	Potatoes (cooked, not fried)	Snacks like chocolate
Poultry, boiled, grilled	Fried potatoes, potato croquets	Snacks like candies
Poultry fried	**Vegetables**	Snacks like biscuits
Fish	Other cooked vegetables	Ice cream
Canned fish	Raw vegetables	Snacks like crisps
Fish, boiled, grilled	**Fruits**	**Fast food**
Fish fried	Fresh fruits without added sugars	Pizza as main dish
Egg and mayonnaise	Fresh fruits with added sugars	Hamburger, hot dog, kebab, wrap, falafel, sandwich
Fried or scrambled eggs	Fresh juices (100% fruit), packaged	Snacks like savory pastries
Boiled or poached eggs	**Grains and cereals**	**Coffee and tea**
Mayonnaise and mayonnaise products	Porridge, oatmeal, gruel, unsweetened cereals, plain muesli	Coffee
Milk and yoghurt	White bread, white roll, white crispbread	Tea
Plain unsweetened milk	Whole meal bread, dark roll, dark crispbread	**Soft drinks**
Sweetened and/or flavored milk	Pasta, noodles, rice and other cereals, white, refined	Carbonated sugar sweetened drinks
Plain unsweetened yoghurt or kefir	Whole meal pasta, noodles, brown rice and other cereals, unrefined	Diet carbonated drinks
Sweet and flavored yoghurt and fermented milk beverages	Dish of milled cereal	Sugar sweetened drinks, not carbonated
Cheese	Sweetened and sugar added breakfast cereals and sweetened crisp muesli	Artificially sweetened drinks, not carbonated
Sliced cheese	**Plant oils**	**Alcohol**
Spreadable cheese	Olive oil	Alcoholic beverages
Grated cheese	**Nuts and dried fruits**	
Fats	Nuts and seeds	
Reduced-fat products on bread	Dried fruits	
Butter, margarine on bread		

Appendix 5. Spearman's correlation between total food intake[1] and energy intake[2]

	CHILDREN	ADOLESCENTS	PARENTS
Total number	335	211	418
Spearman's correlation coefficient	0.134	0.187	0.187
P-value	***0.01****	***0.007*****	***0.000*****

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)
[1] Total kilo food intake/week
[2] Energy intakes was only possible to estimate in the sub-sample who completed at least one 24-h recall