# Disparities in Fruit and Vegetable Intake at the Intersection of Gender and Education in Northern Sweden: A Cross-Sectional Study

Thomas Vogt
  Umeå Universitet Medicinska fakulteten: Umea Universitet Medicinska fakulteten

Per E Gustafsson ( ✉ per.e.gustafsson@umu.se )
  Umeå University    https://orcid.org/0000-0002-3972-5362

Research Article

# Abstract

**Background**: Even though the existence of inequalities in fruit and vegetable consumption has been well established, it is not clear how it is patterned across intersections of multiple social positions and identities. This study aims to investigate disparities in fruit and vegetable intake between groups at the intersection of education and gender in northern Sweden, and to estimate the discriminatory accuracy of the intersectional groups.

**Methods**: Cross-sectional data from the 2018 Health on Equal Terms survey conducted in four regions in northern Sweden was used (N=21,853). Four intersectional groups were created: high and low educated men, and high and low educated women. Prevalence differences corresponding to joint, referent, and excess intersectional inequalities, were estimated using linear binomial regression for three binary outcome variables: inadequate fruit and vegetable intake combined, inadequate fruit intake, and inadequate vegetable intake. The analysis was adjusted for potential confounders. The discriminatory accuracy of the intersectional groups was estimated by the area under the receiver operating characteristic curve.

**Results**: Low educated men had the highest prevalence of inadequate intake of fruits and vegetables combined (81.4%), fruits (53.5%), and vegetables (54.2%), while high educated women had the lowest (47.7%, 28.6%, and 19.2% respectively). The joint disparities between high educated women and low educated men were both significant and substantial for all outcome variables (34.6 pp, 28.7pp, and 34.9pp respectively, adjusted). They were mostly explained by the two referent disparities for gender and education – the part of the joint disparity explained by differences in gender and education, respectively. An inconsistent direction, magnitude, and significance between outcomes was observed for the excess intersectional disparity - the part of the joint disparity not explained by either referent disparity (-5.5pp, 0.1pp, and 3.9pp respectively, adjusted). The discriminatory accuracy of the intersectional groups was moderate (0.67, 0.64, and 0.66 respectively).

**Conclusion**: An intersectional approach can provide a more detailed view of inequalities in fruit and vegetable consumption between groups combining several social positions. The moderate discriminatory accuracy observed here suggests that interventions and policies aiming to reduce diet inequalities should not solely be targeted at certain groups, but also be universal.

# Background

A suboptimal diet could be the risk factor with the greatest impact on mortality worldwide, with low fruit and low vegetable intake among the main contributors (1), associated with increased risk of coronary heart disease, stroke, total cardiovascular disease, total cancer, and all-cause mortality (2). An adequate fruit and vegetable intake is therefore considered critical for a healthy diet in recommendations and guidelines worldwide (3-5).

The burden linked to inadequate consumption of fruits and vegetables is however not shared equally, with disparities in consumption demonstrated both between and within countries (1, 6, 7). Within-country differences in fruit and vegetable intake in high-income countries have been shown for socioeconomic status (6-10), gender (6, 9), as well as demographic characteristics such as marital status (7), age (9, 10), and region of residence (7). Because of their strong impact on health outcomes, disparities in fruit and vegetable intake can also represent one of the pathways by which inequalities in health are produced and maintained in the population (11), and therefore one possible target for promotion of equity in health.

Inequalities in fruit and vegetable consumption are consistent with research suggesting that certain groups sharing the same sociodemographic characteristics might also share health-promoting behaviors. However, the direction of inequality in fruit and vegetable intake varies with the dimension of inequality under consideration. Higher socioeconomic status, and especially higher educational level is usually associated with healthier behaviors in high-income countries (11-13), including higher consumption of fruits and vegetables (6-10, 14, 15). This has been attributed to better knowledge about the health benefits of eating fruits and vegetables, a greater sense of control over one's health among the highly educated groups, and a way for each group to distinguish itself from the other by adhering to a different pattern of fruit and vegetable intake (16). The pattern is different for gender, where women tend to engage in health-promoting behaviors to a greater degree than men (13, 17-19), including a higher intake of fruits and vegetables (6, 20, 21). A common explanation for the gender inequality favoring the structurally disadvantaged group of women is that men display more risk behavior as a way to construct their masculinity and assert their power over women and other men (18).

Although fruit and vegetable consumption tends to be socially patterned in conflicting manners across education on the one hand and between genders on the other, there is little empirical research on how fruit and vegetable consumption is patterned across combined social positions. This question relates to the concern that traditional population health approaches do not fully capture the complexity of health inequalities (22). Specifically, as all individuals simultaneously occupy social positions along multiple axes of inequality, conventional approaches that focus on a single inequality dimension, such as education, gender, or race, may be insufficient for understanding and ultimately addressing the inherent complexity of inequalities in health (23).

These issues are however the focus of intersectionality theory, which is an analytical framework specifically considering the intersection of several social identities and positions as the source of advantages and disadvantages experienced by individuals and groups (22). This theory was first introduced by law scholar Kimberlé Crenshaw in a 1989 article centered on Black women and the intersection of race and gender in the United States (24). Over the following decades the theory spread ubiquitously and was further developed across mainly qualitatively oriented social sciences, which has resulted in a considerable heterogeneity in the specific interpretation and application of intersectionality (25). A more recent example is the concentrated effort over the last few years to translate and integrate intersectionality into social epidemiology and population health research (22, 23, 26, 27). In this quite different scientific context, intersectionality approaches have been introduced as a potential solution to

the issues arising from conventional single-dimension approaches to health inequalities, and have been promoted as providing a unique perspective that could ultimately improve equity in health (22, 23, 28). For example, intersectionality theory has the potential to give more precision to public health research and provide a more detailed and nuanced picture of the way social inequalities contribute to inequalities in health (23, 29). Moreover, it can assist in the identification of the structural factors that are behind those inequalities (29, 30), and could be targets for public health interventions.

At its core, intersectionality theory postulates that the intersection of different social positions or identities cannot be understood simply by looking at them separately, or by adjusting for them in an analysis, but that they should be considered together. Intersectionality theory also implies that groups or individuals combining several positions of social disadvantage could potentially experience more disadvantage in total than the sum of each individual aspect. In this sense, each intersection may have a quality of its own. Kimberlé Crenshaw hypothesized three different possibilities for an intersectional group combining two social positions to experience disadvantage, which can be understood from the perspective of complex population patterns of health. The first possibility is that the disadvantage, e.g. a health disadvantage, is caused by only one of the group's multiple positions. The second possibility is that the combination of both positions will cause a double disadvantage, i.e. an additive effect. The third possibility is that the disadvantage experienced is a product of the specific intersection, i.e. larger or smaller than the sum of the two positions characterizing the intersectional group (24).

At least implicitly based on these tenets, much of the discussion on integrating intersectionality into social epidemiology has centered on its analytical operationalization (26, 27, 31-33). Various existing quantitative methods (29) can capture associations between patterns of health or behavioral outcomes, such as fruit and vegetable consumption, across specific intersections of social positions. Two main approaches of applications have been identified in epidemiology (32). In the first, intersections between groups are represented by cross-classified categories, on which an outcome will be regressed, conventionally using multiplicative-scale models and thus estimating relative inequalities. In the second and more recent approach, described by Jackson et al. (30), a joint disparity in the outcome is estimated on the additive scale between the group who is doubly disadvantaged and the one who is doubly advantaged, which is subsequently decomposed into the portions attributable to each social position (the referent disparities), and the part attributable to the intersection of the two disadvantages (the excess intersectional disparity). This decomposition has the benefit of resembling the possibilities for an intersectional group to experience disadvantage as described by Crenshaw (24), and captures additive inequalities in health. The method by Jackson et al. has been used to study inequalities in mental health in the US (30) and in Sweden (34), health care utilization in Sweden (35), as well as health behaviors such as smoking (36).

Over the last couple of years, a third intersectional analytical approach has emerged within epidemiology, labelled (Multilevel) Analysis of Individual Heterogeneity and Discriminatory Accuracy ((M)AIHDA) (26, 37, 38). It originates in the inherent limitations of approaches based on comparisons of simple population averages when it comes to capturing the individual heterogeneity within each comparison

group, which thus gives little guidance on effective targets for intervention (26). Approaches based on (M)AIHDA have therefore been proposed as a complementary tool to assess the extent to which intersectional categories can discriminate effectively between cases and non-cases (26). These methods specifically provide evidence that is informative when it comes to the principle of proportionate universalism, i.e. universal interventions with a proportionate increased intensity in groups of higher risk. Such methods have been applied in numerous studies on intersectional inequalities mostly in Sweden, for example concerning self-rated general and mental health (34, 39), ischemic heart disease (37), antidepressant and antibiotic use (40, 41), as well as health behaviors in the form of smoking (38). Overall, most results have pointed towards a poor to moderate ability of intersectional groups to discriminate between cases and non-cases, which suggests that universal interventions may be more suitable than targeting high-risk groups.

To the authors' knowledge, no studies have looked at intersectional inequalities in fruit and vegetable intake by gender and education, either in Sweden or elsewhere. Information coming from such studies could help inform the design of policies that would target the segments of the population for which diet quality is of concern. Potentially, this can contribute to reducing inequalities in health in Sweden. In addition, the evidence could help in assessing whether and how intersectionality theory can be useful in studying inequalities in different health-related outcomes and settings.

This study aims to estimate disparities in fruit and vegetable intake between groups at the intersection of gender and education in northern Sweden. An additional aim is to assess the extent to which the intersectional groups discriminate between adequate and inadequate intake of fruits and vegetables.

# Methods

# Population and design

The data came from the cross-sectional Health on Equal Terms survey. This survey is carried out nationally every (2004-2016) to every second (2016-present) year. Every four years, four regions from northern Sweden provide a larger sample to expand the survey. This study uses data from the most recent expanded survey conducted in 2018 in the regions of Norrbotten, Västerbotten, Jämtland/Härjedalen, and Västernorrland.

The 2018 survey consisted of a questionnaire with 64 questions on varied subjects such as mental health, diet, occupation, or healthcare use (42). Both an online and print version of the questionnaire were offered. The survey results were linked to register data by Statistics Sweden for each individual participant using the unique Swedish personal identity number. Register data included, among other variables, age, sex, education, civil status and region of residence (43).

The target population from which the sample was drawn comprised everyone aged 16 to 84 from Norrbotten, Västerbotten, Jämtland/Härjedalen, and Västernorrland, identified through the Register of the Total Population on November 30th, 2017 (42). Each region conducted its own sampling procedures in

collaboration with the Public Health Agency of Sweden and Statistics Sweden. At the national level, the sample was determined through unrestricted random sampling, and drawn from a target population of N=7,930,792 (42). At the regional level, random cluster sampling was used, stratified by age and municipality (and in Västerbotten, also by gender). The total target population in the four regions was 711,303 (44-47). Of the total sample from the four northern regions, N= 3510 (6.5% of the sample) were included in the national survey, to which an additional sample of N=50,600 (93.5% of the sample) was selected as part of the expanded survey. N=208 were excluded because they no longer belonged to the population, resulting in a final sample of 53,902 in total. The expanded 2018 survey from the four regions had 23,487 responses in total and a response rate of 43.6% (44-47).

In the present study, only those aged over 20 years were included in order to capture post-secondary school leavers. As a result, 1232 responses were intentionally excluded. Respondents not coded as residing in one of the four relevant regions were also excluded (n=46). And after excluding missing observations (n=356), 21,853 observations remained.

# Variables

## Fruit and vegetable consumption

Two questionnaire items of frequency of fruit and vegetable intake, respectively, were used, with seven response options ranging from "less than once a week or never" to "twice a day" (43). The responses were dichotomized into adequate (0; once a day or more) versus inadequate (1; less than once a day) consumption of fruit and vegetables, respectively.

In addition, weights were attributed to each level of consumption and a summary variable of combined fruit and vegetable consumption was created, in accordance with the procedures used by the Public Health Agency of Sweden (43). A combined weight of 0.14 is the lowest possible combined consumption for one person, whereas 6 is the highest (43). The summary index was divided according to recommendations into adequate (0; at least 3 servings of fruits and/or vegetables daily) and inadequate (1; less than three servings daily) combined consumption (43)

## Intersectional groups by gender and education

Gender and education were combined to form the four intersectional positions, both retrieved from population registers. Gender was a binary variable with man and woman as the two possible options. High education was defined as having completed at least one term of tertiary education, while low education was defined as having completed secondary education or less.

By cross classifying the binary variables gender and education, four intersectional categories were created: men with high education, men with low education, women with high education, and women with low education. Each group combined two potential social advantages and/or disadvantages. Here, *high education* and *men* were understood to be positions of relative social advantage whereas *low education* and *women* were assumed to be positions of social disadvantage (24, 48). However, as women tend to

display more favorable behavioral outcomes including diet (13, 17-19), for the purpose of this study, high-educated women were considered the doubly advantaged group and low-educated men the doubly disadvantaged group.

## Covariates: age, civil status, region of residence

Potential confounders were included in the analyses as covariates: age was categorized in brackets -(21–30, 31–44, 45-64, 65-84); civil status was divided into: married/cohabiting and unmarried/not cohabiting; and region of residence comprised Norrbotten, Västerbotten, Jämtland/Härjedalen, and Västernorrland.

## Statistical analysis

The characteristics for each intersectional group are displayed in Table 1, with p-values obtained from Pearson $\chi^2$.

Table 1
Descriptive statistics of the main variables by intersectional group.

| Variable | Four groups at the intersection of gender and education[a] | | | | |
|---|---|---|---|---|---|
| | Total, n (%) | High educated women, n (%) | Low educated women, n (%) | High educated men, n (%) | Low educated men, n (%) |
| Sample size | 21,853 (100.0) | 4908 (22.5) | 6849 (31.3) | 3147 (14.4) | 6949 (31.8) |
| **Combined fruit and vegetable** | | | | | |
| Adequate intake (≥3) | 7316 (33.5) | 2568 (52.3) | 2545 (37.2) | 911 (28.9) | 1292 (18.6) |
| Inadequate intake (<3) | 14,537 (66.5) | 2340 (47.7) | 4304 (62.8) | 2236 (71.1) | 5657 (81.4) |
| **Fruit** | | | | | |
| Adequate intake (≥1) | 12,913 (59.1) | 3506 (71.4) | 4452 (65.0) | 1722 (54.7) | 3233 (46.5) |
| Inadequate intake (<1) | 8940 (40.9) | 1402 (28.6) | 2397 (35.0) | 1425 (45.3) | 3716 (53.5) |
| **Vegetable** | | | | | |
| Adequate intake (≥1) | 13,659 (62.5) | 3967 (80.8) | 4457 (65.1) | 2054 (65.3) | 3181 (45.8) |
| Inadequate intake (<1) | 8194 (37.5) | 941 (19.2) | 2392 (34.9) | 1093 (34.7) | 3768 (54.2) |
| **Age** | | | | | |
| 21-30 years old | 2187 (10.0) | 556 (11.3) | 675 (9.9) | 294 (9.3) | 662 (9.5) |
| 31-44 years old | 3821 (17.5) | 1419 (28.9) | 795 (11.6) | 709 (22.5) | 898 (12.9) |
| 45-64 years old | 6988 (32.0) | 1668 (34.0) | 2119 (30.9) | 1053 (33.5) | 2148 (30.9) |
| 65-84 years old | 8857 (40.5) | 1265 (25.8) | 3260 (47.6) | 1091 (34.7) | 3241 (46.6) |
| **Civil status** | | | | | |

[a] All p-values (Pearson $\chi^2$) comparing the frequency of each variable across the four intersectional groups were <0.001.

| Variable | | Four groups at the intersection of gender and education[a] | | | |
|---|---|---|---|---|---|
| Married/cohabiting | 10,954 (50.1) | 2483 (50.6) | 3275 (47.8) | 1725 (54.8) | 3471 (49.9) |
| Unmarried/not cohabiting | 10,899 (49.9) | 2425 (49.4) | 3574 (52.2) | 1422 (45.2) | 3478 (50.1) |
| **Region** | | | | | |
| Västernorrland | 4632 (21.2) | 1039 (21.2) | 1395 (20.4) | 737 (23.4) | 1461 (21.0) |
| Jämtland/Härjedalen | 4266 (19.5) | 996 (20.3) | 1310 (19.1) | 575 (18.3) | 1385 (19.9) |
| Västerbotten | 4409 (20.2) | 940 (19.2) | 1477 (21.6) | 528 (16.8) | 1464 (21.1) |
| Norrbotten | 8546 (39.1) | 1933 (39.4) | 2667 (38.9) | 1307 (41.5) | 2639 (38.0) |

[a] All p-values (Pearson $\chi^2$) comparing the frequency of each variable across the four intersectional groups were <0.001.

To study the disparities in fruit and vegetable intake between the four intersectional positions, a method previously described by Jackson, et al. (30) was used, estimating four disparities with the doubly advantaged position as the reference group. The joint disparity is the prevalence difference of the outcome (inadequate intake of fruits and vegetables) between the intersectional groups of double disadvantage (low educated men) and double advantage (high educated women). The joint disparity can be further decomposed into referent and excess disparities. The referent disparities are differences in prevalence between one middle group and the reference group of double advantage; in this study, the referent disparity in education equals the prevalence difference in fruit and vegetable intake between low educated women and high educated women, and the referent disparity for gender, the corresponding prevalence difference between high educated men and high educated women. The fourth disparity is the excess intersectional disparity, which is the (positive or negative) difference in prevalence that remains after both referent disparities have been subtracted to the joint disparity and is equivalent to an additive-scale interaction term. That is, the joint disparity equals the sum of the two referent disparities and the excess intersectional disparity:

Joint disparity = Referent disparity (1) + Referent disparity (2) + Excess intersectional disparity.

Stata 16.1 was used to carry out the analysis. Linear binomial regression was used to estimate the joint and referent disparities, while post-estimation of linear combinations of parameters were used to determine the excess intersectional disparity. The binomial regressions were run on the cross-classified intersectional variable separately for each of the three outcome variables, in unadjusted analyses and analyses adjusting for covariates.

Each disparity is expressed as prevalence differences, in percentage points (pp) with 95% confidence interval. The referent disparities and the excess intersectional disparity were also descriptively expressed as percentages of the joint disparity. A positive estimate for the joint or referent disparity would indicate a higher prevalence of inadequate intake among low educated men, high educated men or low educated women compared to the reference group of high educated women. A zero estimate for the excess intersectional disparity means that the joint disparity is equal to the sum of the two referent disparities, equivalent to an additive effect of gender and education on the outcome. In contrast, a positive (or negative) estimate of excess intersectional disparity would indicate that the prevalence among low educated men was greater (or lower) than what is to be expected from simply considering the two disadvantages as independent and additive to each other.

Discriminatory accuracy was estimated by calculating the Area Under the Receiver Operating Characteristic curve (AU-ROC), using a logistic regression model (49). This yield results ranging from 0.5 to 1, where 0.5 indicates no discrimination, and 1 represents perfect discrimination of the model. Results were interpreted with the ranking by Lemeshow et al. in mind (50). However, to adapt the ranking of AU-ROC levels to a social epidemiological context, modified cut-offs and labels were used according to those described by Axelsson Fisk et al. (38). Here, the discriminatory accuracy was thus considered 'absent or very small' if AUC=0.5-0.6, 'moderate' if AUC $>0.6-\leq0.7$, 'large' if AUC $>0.7-\leq0.8$, and 'very large' if AUC $>0.8$. The AU-ROC was calculated separately for each of the outcome variables according to three models. The first model included only the covariates, while the second model included the covariates and education and gender as binary variables. The third model comprised the covariates and the cross-classified intersectional variables. A descriptive estimate of the change in the ROC area with Model 1 as reference was also calculated, expressed as Δ AU-ROC.

# Results

## Descriptive data analysis

The descriptive statistics for the population studied are displayed in Table 1. High educated women made up 22.5% (n=4908) of the final population retained for analysis. An additional 31.3% (n=6849) were low educated women, and high educated and low educated men accounted for 14.4% (n=3147) and 31.8% (n=6949) respectively.

The prevalence of inadequate intake of fruits and vegetables combined, fruits, and vegetables was highest among low educated men (81.4%, 53.5%, and 54.2% respectively) and lowest among high educated women (47.7%, 28.6%, and 19.2% respectively) (Figure 1).

## Intersectional disparities in fruit and vegetable intake

The crude and adjusted analysis yielded similar results (Table 2) (Figure 2), indicating that the covariates did not play a strong confounding role. The direction and level of significance of the results were similar, although not identical, between analysis for each outcome variable and each disparity studied.

Table 2
Crude and adjusted intersectional disparities in consumption of fruits and vegetables combined, fruits, and vegetables.

| Disparity | Prevalence difference in inadequate intake [a] | | | | | |
|---|---|---|---|---|---|---|
| | Fruits and vegetables (combined) | | Fruits | | Vegetables | |
| | Crude | Adjusted[b] | Crude | Adjusted[b] | Crude | Adjusted[b] |
| Joint | 33.7 ** [32.1 to 35.4] | 34.6 ** [32.9 to 36.3] | 24.9** [23.2 to 26.6] | 28.7 ** [27.1 to 30.4] | 35.1** [33.4 to 36.7] | 34.9 ** [33.3 to 36.5] |
| Referent sex | 23.4 ** [21.3 to 25.5] | 24.1 ** [22.0 to 26.2] | 16.7 ** [14.6 to 18.9] | 18.4 ** [16.3 to 20.4] | 15.6** [13.6 to 17.6] | 15.5 ** [13.6 to 17.5] |
| % of joint disparity | 69 | 70 | 67 | 64 | 44 | 45 |
| Referent education | 15.2 ** [13.4 to 17.0] | 16.1 ** [14.2 to 17.9] | 6.4 ** [4.7 to 8.1] | 10.3 ** [8.6 to 11.9] | 15.8** [14.2 to 17.3] | 15.5 ** [13.9 to 17.1] |
| % of joint disparity | 45 | 46 | 26 | 36 | 45 | 44 |
| Excess | -4.8 ** [-7.4 to -2.2] | -5.5** [-8.1 to -3.0] | 1.8 [-0.9 to 4.5] | 0.1 [-2.5 to 2.7] | 3.7* [1.2 to 6.3] | 3.9* [1.3 to 6.5] |
| % of joint disparity | -14 | -16 | 7 | 0 | 11 | 11 |
| *p<0.05, **p<0.001 | | | | | | |
| [a] Estimates are percentage points (pp) and 95% confidence intervals [CI] unless otherwise specified. | | | | | | |
| [b] Adjusted for age, civil status, and region of residence. | | | | | | |

*Combined fruit and vegetable intake*

In the adjusted analysis, the joint disparity in combined fruit and vegetable intake estimated a 34.6 pp (95% CI: 32.9 to 36.3) higher prevalence of inadequate intake of fruits and vegetables among low educated men than among high educated women. The decomposition of the joint disparity showed that the referent disparity for gender made a greater contribution to the joint disparity (24.1 pp; 95% CI: 22.0 to -26.2) than the referent disparity for education (16.1 pp; 95% CI: 14.2 to 17.9). Furthermore, the excess intersectional disparity indicated a marked lower prevalence (-5.5 pp; 95% CI: -8.1 to -3.0) of inadequate

combined intake in low educated men than what would be expected from the addition of the two referent disparities.

*Fruit intake*

The results were in a similar direction for fruit intake, although the adjusted joint disparity was much smaller than for combined intake (28.7 pp; 95% CI: 27.1 to 30.4). Again, as for combined intake of fruits and vegetables, the referent disparity for gender (18.4 pp; 95% CI: 16.3 to 20.4) was greater than the referent disparity for education (10.3 pp; 95% CI: 8.6 to 11.9). However, in contrast to the combined outcome, the excess intersectional disparity (0.1 pp; 95% CI: -2.5 to 2.7) indicated that the inequalities in fruit intake between high educated women and low educated men corresponded to the addition of the two referent disparities, and was what would be expected by considering gender and education independently from each other.

*Vegetable intake*

Similarly to the combined and fruit intake, the joint disparity in vegetable intake in the adjusted analysis (34.9 pp; 95% CI: 33.3 to 36.5) indicated that inadequate intake of vegetables was significantly more prevalent in low educated men than in high educated women. However, the joint disparity for vegetable intake was higher than for fruit intake, and similar to the joint disparity for combined intake. In contrast with the two other outcome variables, the referent disparity for gender (15.5 pp; 95% CI: 13.6 to 17.5) and the referent disparity for education (15.5 pp; 95% CI: 13.9 to 17.1) were of similar magnitude. Also, in this case, the excess intersectional disparity left after subtracting the two referent disparities (3.9 pp; 95% CI: 1.3 to 6.5) suggested that inadequate intake of vegetables among low educated men was more prevalent than expected from the addition of the two referent disparities.

## Discriminatory accuracy

The AU-ROC increased substantially for all three outcomes from Model 1 to Model 2 or from Model 1 to Model 3. For combined fruit and vegetable intake, the discriminatory accuracy as measured by the AU-ROC was 0.54 ('absent or very small') when including only the demographic covariates, and 0.67 ('moderate') when adding independent variables in Model 2. It remained unchanged when taking the cross-classified intersectional positions into account in Model 3.

Table 3
Discriminatory accuracy of variables estimated by the Area Under the Receiver
Operating Characteristic curve (AU-ROC).

| Outcome variables | AU-ROC [95% Conf. Interval] | | |
| --- | --- | --- | --- |
| | Model 1[a] | Model 2[b] | Model 3[c] |
| Combined intake | 0.54 [0.53 to 0.54] | 0.67 [0.66 to 0.68] | 0.67 [0.66 to 0.68] |
| ΔAU-ROC | Reference | 0.1308 | 0.1309 |
| Fruit intake | 0.52 [ 0.51 to 0.53] | 0.64 [0.63 to 0.64] | 0.64 [0.63 to 0.64] |
| ΔAU-ROC | Reference | 0.1134 | 0.1142 |
| Vegetable intake | 0.53 [ 0.52 to 0.54] | 0.66 [0.65 to 0.67] | 0.66 [0.65 to 0.67] |
| ΔAU-ROC | Reference | 0.1283 | 0.1285 |
| [a] Model 1: age, civil status, and region of residence. | | | |
| [b] Model 2: model 1 + education + gender. | | | |
| [c] Model 3: model 1 + cross-classified intersectional groups. | | | |

# Discussion

This study aimed to estimate disparities in fruit and vegetable intake between groups at the intersection of educational level and gender in northern Sweden, and to assess the discriminatory accuracy of the intersectional groups. Substantial differences between intersectional groups were found in the prevalence of inadequate intake of fruits and vegetables combined, and separately. Gender made a greater contribution overall to the inequalities than education did, except for fruit intake where little to no difference was seen between the two referent disparities. Variations in direction, magnitude and significance were seen in the excess intersectional disparities across outcomes, suggesting a complex intersectional pattern for these related but distinct dietary outcomes. The discriminatory accuracy of the covariates and gender and education was moderate and suggested an importance of these two inequality dimensions, but consideration of their cross-classification did not contribute to any additional discriminatory power.

The finding that the referent disparity for gender consistently explained a large portion of the joint disparity is in line with previous research indicating that women have in general a higher fruit and vegetable consumption than men (6, 20, 21), and healthier behaviors overall (13, 17-19). Although to a lesser extent, the referent disparity for education also explained a substantial fraction of the joint disparities. This is consistent with the literature on educational inequalities in fruit and vegetable consumption (6-10, 14, 15), and other types of health behaviors (11-13). Several potential mechanisms have been proposed to explain this relationship between education level and health behaviors (16).

The finding that the excess intersectional disparity varied greatly across outcomes illustrates the potential usefulness of intersectional approaches in epidemiology. The intersection of multiple disadvantages for fruit and vegetable intake appeared to be associated with a unique pattern of consumption not entirely explained by the addition of gender and education. Specifically, for combined intake of fruits and vegetables, the intersection of male gender and low education appeared to be unexpectedly protective against unhealthy dietary patterns.

As pointed out by Jackson et al. (30), it should also be noted that the existence and magnitude of the joint disparity should not be dismissed if the excess intersectional disparity is non-existent or negative. Even if a group does not display any excess intersectional disparity, it can still experience the sum of the two referent disparities. In this study, the joint disparity in consumption of fruits, vegetables, and fruits and vegetables between high educated women and low educated men, although inconsistently affected by the excess intersectional disparity, was still great in magnitude; inadequate intake of fruits and vegetables combined was 34.59 pp more prevalent for low educated men than for high educated women.

The discriminatory accuracy of the intersectional groups for identifying inadequate intake of fruits and vegetables as measured by the AU-ROC was close to - but below - 0.7 and could therefore be considered moderate. Most importantly, the lack of additional discriminatory power of the cross-classification found in this study is recurrent in empirical studies using intersectional approaches to study inequalities in Sweden (34, 38, 39). Those two findings would be commonly interpreted as evidence in favor of universal rather than targeted intervention in the context of proportionate universalism. For the present study, this would suggest that the targeting of specific intersectional groups is not suitable as the sole guiding principle for health promotion planning. However, while this interpretation is straightforward when the goal is general health promotion in the population, e.g. increase fruit and vegetable intake, it is not as evident when the goal is promotion of equity in health, e.g. reducing inequalities in fruit and vegetable intake.

Moreover, the AU-ROC method comes from signal detection theory (50), and there is no clear-cut threshold that would label a discrimination as high enough for intersectional approaches in epidemiology. Indeed, examinations of both novel and traditional risk factors for coronary heart disease have yielded similarly disappointing results when it comes to discriminatory accuracy (51), despite many of them being established in clinical practice. While discriminatory accuracy represents a necessary complement to means-centric examinations of health inequalities, and to traditional epidemiology more generally, a cautious interpretation of its implications specifically in the context of equity promotion is therefore warranted.

## Further research and public health relevance

To our knowledge, this Swedish study is the first of its kind investigating disparities in fruit and vegetable consumption across intersectional groups defined by gender and education. The intersectional approach was helpful to shed light on the complex inequality patterns of inadequate intake of fruits and vegetables. In addition, as the estimated disparities are additive rather than relative measure of inequality,

they can be used to determine the absolute benefits in population health if a disparity were to be eliminated (30).

The findings from this study will hopefully help to give a more nuanced understanding of the structural patterning of disparities in diet, and thereby improve the effectiveness of equity-promoting public health interventions and policies. Although the moderate discriminatory accuracy in this study could suggest that universal interventions and policies might be more effective for improving diet quality in Sweden, there is a risk that they would mostly benefit those already advantaged, and could therefore contribute to widening inequalities in health (52). A combination of universal and targeted measures to improve diet quality could be a way forward, in line with proportionate universalist principles (53). This study could then contribute to giving guidance as to where are the largest disparities, and what are the most relevant groups to prioritize.

Future research on diet quality could consider operationalizing groups at the intersection of gender, education, and other inequality dimensions. This could help identify intersectional groups with higher discriminatory accuracy and facilitate targeted interventions to improve health equity.

## Strengths and limitations

Since random sampling procedures were used to draw a sample from the general population, selection bias is limited to some extent. However, the response rate varied between 42.4% for Västerbotten (46) and 45.8% for Jämtland/Härjedalen (44). Since most people contacted to answer the survey did not answer it, it is unknown whether the final sample is truly representative of the target population.

It is also not known to which degree the results can be generalized outside of Sweden. Indeed, the implications of the intersection of gender and education can be expected to differ between contexts. In addition, the results cannot be generalized to other countries and settings with different patterns of health and nutrition. The socioeconomic and gender inequalities in fruit and vegetable intake observed in this Swedish sample might be very different in other social, economic and cultural settings (54-56).

The use of gender as one of the two variables for the operationalization of the intersectional groups can be questioned. Since this study was interested in investigating social inequalities in health behaviors, and not potential biological inequalities in health, gender seemed more appropriate as designating a social construct rather than a biological construct. However, what is measured by available register data is biological sex recorded at birth, and thus might not always represent gender identity accurately. The adequateness of using one term or the other in epidemiology has been discussed elsewhere (57).

It was assumed that the frequency of fruit and vegetable intake reported was synonymous with the amount consumed. Reporting bias could be a concern here. Over-reporting may, for example, have occurred more in those with higher education since they might be more conscious of the existing recommendations for fruit and vegetable intake. Under-reporting may have occurred among those with relatively lower education due to potentially weaker health and nutrition knowledge (58). In contrast, the

exposure variables and the potentially confounding variables came from high-quality register data and therefore were not affected by self-report bias.

Since this study is cross-sectional in design, it cannot be used to determine causality, even though reverse causality is unlikely. In addition, despite adjusting for potential confounders, it is not impossible that some residual confounding may subsist. However, the associations found between intersectional group and prevalence of inadequate fruit and vegetable intake are not easily affected by confounders. Indeed, most third variables such as income or occupation are likely to be determined in part by gender and education, and if included would risk over-adjustment and result in under-estimation of the inequalities.

Finally, the method described by Jackson et al. (30) allows to quantitatively investigate disparities at the intersection of multiple social positions and identities, in a way that corresponds to the different possibilities for an intersectional group to experience disadvantage (24). However, this approach limits the number of social positions that can be considered simultaneously (30). In addition, it measures additive interactions, whereas the AU-ROC is based on multiplicative interactions. This may partly explain why measures of discriminatory accuracy did not identify any intersectional interaction from Model 2 to Model 3, whereas substantial excess intersectional disparities were estimated for two out of the three outcomes.

## Conclusions

This study found substantial differences in the prevalence of inadequate intake of fruits and vegetables, favoring high educated women, and disfavoring low educated men. Gender seemed to have a greater impact than education in explaining the disparity, and estimations of the excess intersectional disparities were inconsistent across outcome variables. For each outcome, the excess intersectional disparity bore less weight on the joint disparity than any of the referent disparities, but was substantial for two of the outcomes. This indicates that studying the intersection of multiple disadvantages might be needed to explain different patterns of consumption.

The intersectional approach helps illustrate how the intersection of specific identities and social positions can explain disparities in fruit and vegetable consumption. This could be relevant for public health policies and interventions whose goals are to reduce inequalities in health by providing a more accurate picture of the social world when it comes to the consumption of fruits and vegetables. The moderate discriminatory accuracy seen in this study suggests that interventions and policies aiming to reduce diet inequalities should not solely be targeted at certain groups, but also be universal.

## Abbreviations

AU-ROC
Area Under the Receiver Operating Characteristic curve
CI

Confidence Interval

(M)AIHDA

(Multilevel) Analysis of Individual Heterogeneity and Discriminatory Accuracy

ROC

Receiver Operating Characteristic

ΔAU-ROC

change in the ROC Area with Model 1 as reference.

# Declarations

### Ethics approval and consent to participate

All participants provided informed consent. The study was approved by the Ethical Review Authority (reference number 2020-00204 and 2015/134-31).

### Consent for publication

Not applicable

### Availability of data and materials

Access to the data used in the current study is managed by the register holders, the respective County Council/Region, and data are as such not publicly available.

### Competing interests

The authors declare that they have no competing interests.

### Authors' contributions

TV and PEG jointly conceived the idea for the study. TV made the literature review, conducted all analyses, and wrote the first draft of the paper. PEG provided guidance with regards to theory, concepts, literature, analysis, and interpretation. Both authors revised the article for important intellectual content and have read and approved the final version.

# References

1. Collaborators GD. Health effects of dietary risks in 195 countries, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2019;393(10184):1958–72.

2. Aune D, Giovannucci E, Boffetta P, Fadnes LT, Keum N, Norat T, et al. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. Int J Epidemiol. 2017;46(3):1029–56.

3. World Health Organization. Healthy diet. 2020. https://www.who.int/news-room/fact-sheets/detail/healthy-diet. Accessed 23 Oct 2021.

4. Nordic Nutrition Recommendations 2012: Integrating nutrition and physical activity. 5 ed. Copenhagen: Nordisk Ministerråd; 2014 2014. 627 p.

5. Folkhälsomyndigheten. Mat – rekommendationer. 2020. https://www.folkhalsomyndigheten.se/livsvillkor-levnadsvanor/fysisk-aktivitet-och-matvanor/mat–rekommendationer/. Accessed 23 Oct 2021.

6. Stea TH, Nordheim O, Bere E, Stornes P, Eikemo TA. Fruit and vegetable consumption in Europe according to gender, educational attainment and regional affiliation-A cross-sectional study in 21 European countries. PLoS One. 2020;15(5):e0232521.

7. Kamphuis CB, Giskes K, de Bruijn GJ, Wendel-Vos W, Brug J, van Lenthe FJ. Environmental determinants of fruit and vegetable consumption among adults: a systematic review. Br J Nutr. 2006;96(4):620–35.

8. Giskes K, Avendano M, Brug J, Kunst AE. A systematic review of studies on socioeconomic inequalities in dietary intakes associated with weight gain and overweight/obesity conducted among European adults. Obes Rev. 2010;11(6):413–29.

9. Ax E, Warensjö Lemming E, Becker W, Andersson A, Lindroos AK, Cederholm T, et al. Dietary patterns in Swedish adults; results from a national dietary survey. Br J Nutr. 2016;115(1):95–104.

10. Huseinovic E, Hörnell A, Johansson I, Esberg A, Lindahl B, Winkvist A. Changes in food intake patterns during 2000-2007 and 2008-2016 in the population-based Northern Sweden Diet Database. Nutr J. 2019;18(1):36.

11. Petrovic D, de Mestral C, Bochud M, Bartley M, Kivimäki M, Vineis P, et al. The contribution of health behaviors to socioeconomic inequalities in health: A systematic review. Prev Med. 2018;113:15–31.

12. Skalamera J, Hummer RA. Educational attainment and the clustering of health-related behavior among U.S. young adults. Prev Med. 2016;84:83–9.

13. Zickfeld JH, Schubert TW, Herting AK, Grahe J, Faasse K. Correlates of Health-Protective Behavior During the Initial Days of the COVID-19 Outbreak in Norway. Front Psychol. 2020;11:564083.

14. Lallukka T, Laaksonen M, Rahkonen O, Roos E, Lahelma E. Multiple socio-economic circumstances and healthy food habits. Eur J Clin Nutr. 2007;61(6):701–10.

15. Ricciuto L, Tarasuk V, Yatchew A. Socio-demographic influences on food purchasing among Canadian households. Eur J Clin Nutr. 2006;60(6):778–90.

16. Pampel FC, Krueger PM, Denney JT. Socioeconomic Disparities in Health Behaviors. Annu Rev Sociol. 2010;36:349–70.

17. Moran KR, Del Valle SY. A Meta-Analysis of the Association between Gender and Protective Behaviors in Response to Respiratory Epidemics and Pandemics. PLoS One. 2016;11(10):e0164541.

18. Courtenay WH. Constructions of masculinity and their influence on men's well-being: a theory of gender and health. Soc Sci Med. 2000;50(10):1385–401.

19. Kandrack MA, Grant KR, Segall A. Gender differences in health related behaviour: some unanswered questions. Soc Sci Med. 1991;32(5):579–90.

20. Swedish National Food Agency. Riksmaten 2010–11, Livsmedels- och näringsintag bland vuxna i Sverige. Uppsala: National Food Agency; 2012. Report No.: ISBN 978 91 7714 216 4.

21. Horino M, Liu SY, Lee EY, Kawachi I, Pabayo R. State-level income inequality and the odds for meeting fruit and vegetable recommendations among US adults. PLoS One. 2020;15(9):e0238577.

22. Bauer GR. Incorporating intersectionality theory into population health research methodology: challenges and the potential to advance health equity. Soc Sci Med. 2014;110:10–7.

23. Kapilashrami A, Hankivsky O. Intersectionality and why it matters to global health. Lancet. 2018;391(10140):2589–91.

24. Crenshaw K. Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics. University of Chicago Legal Forum. 1989;1989(1).

25. McCall L. The Complexity of Intersectionality. Signs. 2005;30(3):1771–800.

26. Merlo J. Multilevel analysis of individual heterogeneity and discriminatory accuracy (MAIHDA) within an intersectional framework. Soc Sci Med. 2018;203:74–80.

27. Evans CR, Williams DR, Onnela JP, Subramanian SV. A multilevel approach to modeling health inequalities at the intersection of multiple social identities. Soc Sci Med. 2018;203:64–73.

28. Singleton CR, Winkler M, Houghtaling B, Adeyemi OS, Roehll AM, Pionke JJ, et al. Understanding the Intersection of Race/Ethnicity, Socioeconomic Status, and Geographic Location: A Scoping Review of U.S. Consumer Food Purchasing. Int J Environ Res Public Health. 2020;17(20).

29. 29.

30. Jackson JW, Williams DR, VanderWeele TJ. Disparities at the intersection of marginalized groups. Soc Psychiatry Psychiatr Epidemiol. 2016;51(10):1349–59.

31. Bauer GR, Scheim AI. Advancing quantitative intersectionality research methods: Intracategorical and intercategorical approaches to shared and differential constructs. Soc Sci Med. 2019;226:260–2.

32. Bauer GR, Scheim AI. Methods for analytic intercategorical intersectionality in quantitative research: Discrimination as a mediator of health inequalities. Soc Sci Med. 2019;226:236–45.

33. Jackson JW. Explaining intersectionality through description, counterfactual thinking, and mediation analysis. Soc Psychiatry Psychiatr Epidemiol. 2017;52(7):785–93.

34. Fagrell Trygg N, Mansdotter A, Gustafsson PE. Intersectional inequalities in mental health across multiple dimensions of inequality in the Swedish adult population. Soc Sci Med. 2021;283:114184.

35. Nyamande FN, Mosquera PA, San Sebastian M, Gustafsson PE. Intersectional equity in health care: assessing complex inequities in primary and secondary care utilization by gender and education in northern Sweden. Int J Equity Health. 2020;19(1):159.

36. Amroussia N, Gustafsson PE, Pearson JL. Do inequalities add up? Intersectional inequalities in smoking by sexual orientation and education among U.S. adults. Prev Med Rep. 2020;17:101032.

37. Wemrell M, Mulinari S, Merlo J. Intersectionality and risk for ischemic heart disease in Sweden: Categorical and anti-categorical approaches. Soc Sci Med. 2017;177:213–22.

38. Axelsson Fisk S, Lindström M, Perez-Vicente R, Merlo J. Understanding the complexity of socioeconomic disparities in smoking prevalence in Sweden: a cross-sectional study applying intersectionality theory. BMJ Open. 2021;11(2):e042323.

39. Wemrell M, Karlsson N, Perez Vicente R, Merlo J. An intersectional analysis providing more precise information on inequities in self-rated health. Int J Equity Health. 2021;20(1):54.

40. Ljungman H, Wemrell M, Khalaf K, Perez-Vicente R, Leckie G, Merlo J. Antidepressant use in Sweden: an intersectional multilevel analysis of individual heterogeneity and discriminatory accuracy (MAIHDA). Scand J Public Health. 2021:1403494821993723.

41. Wemrell M, Lenander C, Hansson K, Perez RV, Hedin K, Merlo J. Socio-economic disparities in the dispensation of antibiotics in Sweden 2016-2017: An intersectional analysis of individual heterogeneity and discriminatory accuracy. Scand J Public Health. 2021:1403494820981496.

42. Statistiska centralbyrån (SCB). Teknisk Rapport - En beskrivning av genomförande och metoder. 2018.

43. Folkhälsomyndigheten. Syfte och bakgrund till frågorna i den nationella folkhälsoenkäten. Hälsa på lika villkor 2018. 2018. Contract No.: 18083.

44. Statistiska centralbyrån (SCB). Teknisk Rapport - En beskrivning av genomförande och metoder - Region Jämtland/Härjedalen. 2018.

45. Statistiska centralbyrån (SCB). Teknisk Rapport - En beskrivning av genomförande och metoder - Region Norrbotten. 2018.

46. Statistiska centralbyrån (SCB). Teknisk Rapport - En beskrivning av genomförande och metoder - Region Västerbotten. 2018.

47. Statistiska centralbyrån (SCB). Teknisk Rapport - En beskrivning av genomförande och metoder - Region Västernorrland. 2018.

48. Lengermann PM, Niebrugge G. Intersectionality Theory. In: Ritzer G, editor. Sociological Theory. Seventh ed. New York: McGraw-Hill; 2008. p. 478–80.

49. Pepe MS, Janes H, Longton G, Leisenring W, Newcomb P. Limitations of the odds ratio in gauging the performance of a diagnostic, prognostic, or screening marker. Am J Epidemiol. 2004;159(9):882–90.

50. Lemeshow S, et al. Applied Logistic Regression. 3rd ed. John Wiley & Sons; 2013.

51. Merlo J, Mulinari S, Wemrell M, Subramanian SV, Hedblad B. The tyranny of the averages and the indiscriminate use of risk factors in public health: The case of coronary heart disease. SSM Popul Health. 2017;3:684–98.

52. Mackenbach JP. The persistence of health inequalities in modern welfare states: the explanation of a paradox. Soc Sci Med. 2012;75(4):761–9.

53. Marmot M, Bell R. Fair society, healthy lives. Public Health. 2012;126 Suppl 1:S4-s10.

54. Monteiro CA, Mondini L, de Souza AL, Popkin BM. The nutrition transition in Brazil. Eur J Clin Nutr. 1995;49(2):105–13.

55. Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. Nutr Rev. 2012;70(1):3–21.

56. Mayén AL, Marques-Vidal P, Paccaud F, Bovet P, Stringhini S. Socioeconomic determinants of dietary patterns in low- and middle-income countries: a systematic review. Am J Clin Nutr. 2014;100(6):1520–31.

57. Krieger N. Genders, sexes, and health: what are the connections--and why does it matter? Int J Epidemiol. 2003;32(4):652–7.

58. Macdiarmid J, Blundell J. Assessing dietary intake: Who, what and why of under-reporting. Nutr Res Rev. 1998;11(2):231–53.
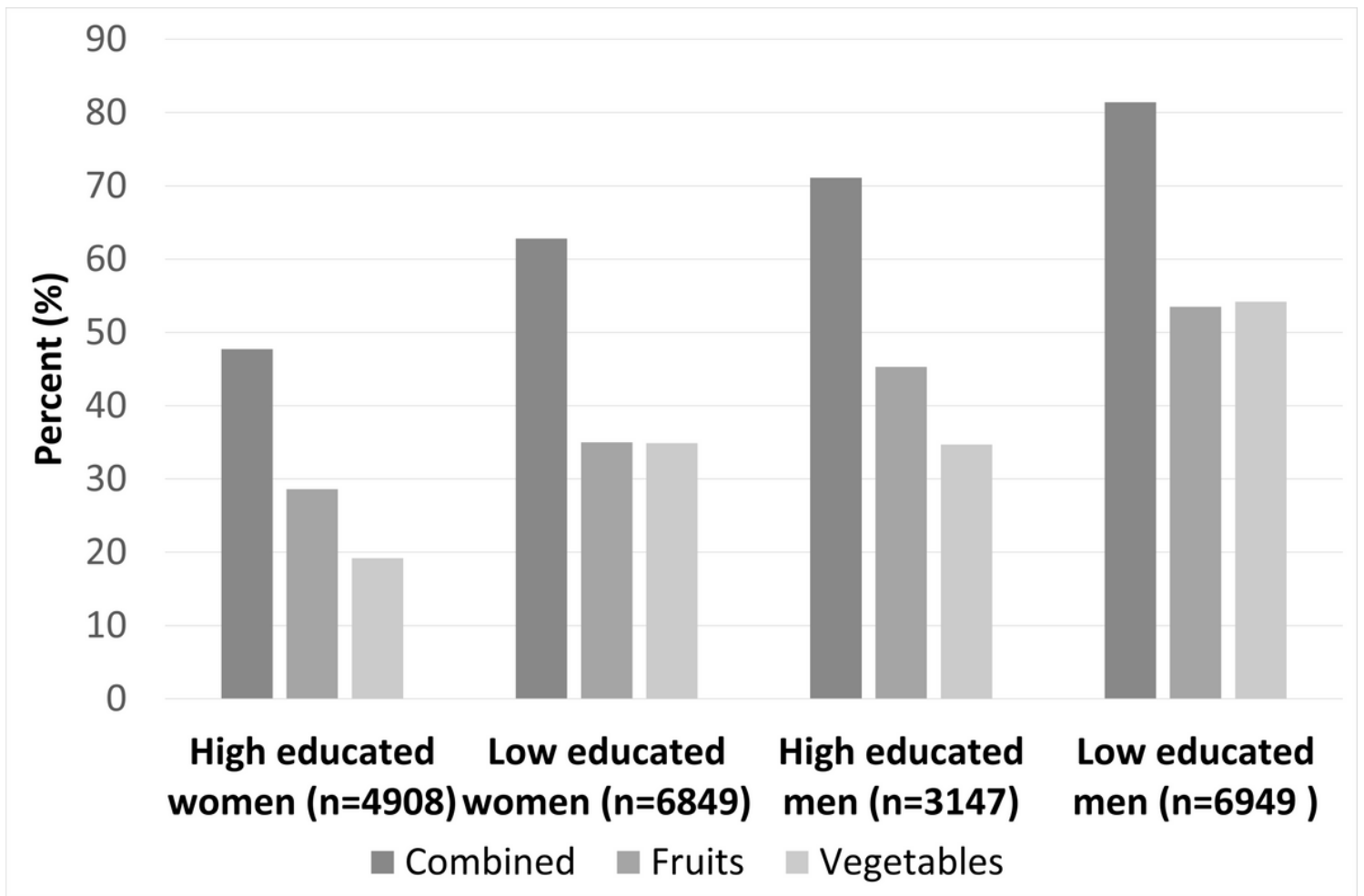
# Figures

**Figure 1**

Inadequate intake of fruits and vegetables (combined), fruits, and vegetables, by intersectional group (N=21,853). *
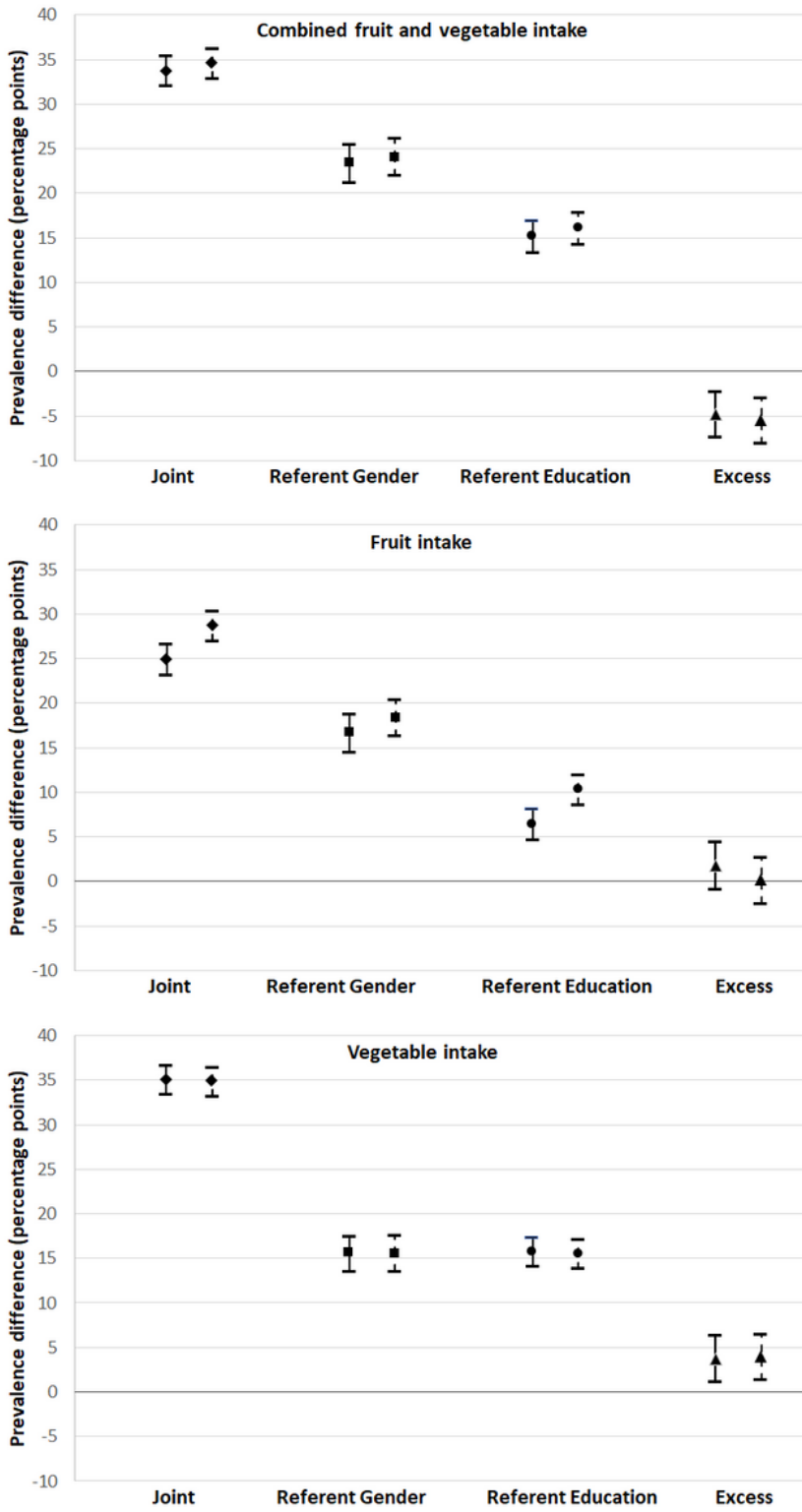
**Figure 2**

Disparities in consumption between intersectional groups. Crude (solid line) and adjusted (dashed line).
*