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# Improving Nutritional Health Equity During Pregnancy in French Guiana: effectiveness of the Nutri Pou ti'moun Intervention on Women's Dietary Diversity

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**Research Article**

**Keywords:**

**Posted Date:** September 20th, 2026

**DOI:** https://doi.org/10.21203/rs.3.rs-10320947/v1

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**Additional Declarations:** No competing interests reported.

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## Abstract

# Background:

French Guiana is a French territory with a context that is unique and marked by socioeconomic precariousness, poor perinatal health, and significant food and nutritional insecurity during pregnancy. Therefore, it is essential to implement public health initiatives that improve nutritional health equity during pregnancy. The Nutri Pou Ti'moun (NPTM) program, launched in 2023, aims to evaluate the effectiveness of a complex pilot intervention during pregnancy - comprising 12 weekly peer-led group sessions (including 6 nutrition sessions), health mediation, and the distribution of food baskets - on the dietary diversity of pregnant women in French Guiana.

# Methods:

Using a quasi-experimental study design, we compared pregnant women who did receive the intervention (intervention group, n = 101) with those who did not (control group, n = 644). The primary outcome measure was dietary diversity, assessed using the Minimum Dietary Diversity for Women indicator (MDD-W ≥ 5 food groups) and the Women's Dietary Diversity Score (WDDS). To reduce confounding factors and account for the lack of randomization, after constructing a Directed Acyclic Graph, propensity score matching (PSM) was applied to estimate the average treatment effect on the treated (ATET). Additionally, inverse probability of treatment weighting (IPTW) was performed as a robustness analysis.

# Results:

Among the women in the intervention group, 65.3% had participated in at least 5 of the 6 group sessions on nutrition. The intervention group had a significantly higher multidimensional vulnerability profile than the control group. According to the PSM, the ATET was + 35.0 percentage points [95%CI: 19.7; 50.4] for MDD-W, and was + 1.44 points [0.92; 1.95] for WDDS in the intervention group. The food groups that contributed most to this effect were vitamin A-rich fruits and vegetables, other vegetables, legumes, and eggs.

# Conclusions:

Participation in this multicomponent intervention, based on social cognitive theory, was associated with short-term improvements in dietary diversity among highly vulnerable pregnant women. Further research is needed to assess the long-term effects on dietary diversity and identify ways to scale up the intervention.

# Contributions to the Literature

● Studies evaluating complex interventions aimed at improving dietary quality during pregnancy are rare in Latin American and Caribbean countries, particularly in highly vulnerable communities.

# Trial registration:

clinicaltrials.gov number: NCT06528535 on July 23, 2024.

## Contributions to the Literature

- Studies evaluating complex interventions aimed at improving dietary quality during pregnancy are rare in Latin American and Caribbean countries, particularly in highly vulnerable communities.
- This study provides evidence of the effectiveness of an innovative, community-based, complex intervention that combines group nutrition sessions, peer support, health mediation, mobile health, and the distribution of baskets of fresh produce.
- This real-world evaluation employs a methodology combining directed acyclic graphs, propensity score matching, and sensitivity analyses to strengthen causal inference within a quasi-experimental framework.
- The results demonstrate an average effect of the intervention on dietary diversity without reducing the consumption of unhealthy foods in the intervention group. These findings encourage further research to develop more effective interventions that promote equity in nutrition and maternal and fetal health.

## INTRODUCTION

The dietary environment during the first 1,000 days of life - from conception to a child's second birthday - has a significant impact on lifelong health and developmental outcomes. In alignment with the Developmental Origins of Health and Disease (DOhaD) hypothesis, early-life environmental exposures, such as maternal nutrition, can induce epigenetic modifications, influencing fetal gene expression and metabolic programming. These biological adaptations may have long-term consequences, increasing susceptibility to non-communicable diseases and cognitive delays (1). During pregnancy, inadequate dietary intake and micronutrient deficiencies can impact both maternal health and fetal development, compromising pregnancy outcomes(2). For the mother, the reported risks include increased rates of cesarean section, intrauterine growth restriction and perinatal risks, gestational diabetes and up to 20% increase in maternal mortality linked to postpartum hemorrhage caused by anemia or iron imbalances(2). For the child, the main consequences of maternal malnutrition and micronutrient deficiencies are: infant mortality due to vitamin A and zinc deficiency, growth retardation due to iron or

iodine deficiency, prematurity, low birth weight in the unborn child, and rickets, mainly caused by calcium deficiency (2).

French Guiana, a French territory in the Americas, has a set of distinctive features that make the study of the dietary environment during pregnancy particularly relevant for improving the health of mothers and children. Its multicultural and multiethnic nature reflects its history and the multiple waves of migration that have shaped it (3). It has a paradoxical economic situation having at the same time one of the lowest GDPs among French territories but also one of the highest in Latin America. The poverty rate compared to mainland France is massive, with 53% of the population living below the poverty line (4). Recent studies have highlighted the substantial burden of food insecurity in French Guiana (5). French Guiana also has one of the highest birth rates in France (22.6% compared to a national average of 9.2% (6) and the highest total fertility rate in Latin America: 3.8 in 2020 (7). The study of perinatal care and its comparison with mainland France reveals high rates of preterm births, frequent hypertensive disorders of pregnancy, high rates of low birth weight, anemia, teen pregnancies, and infant mortality (8). A study conducted at the referral hospital in Cayenne in 2019–2020 revealed that 81% of pregnant women had at least one micronutrient deficiency by the end of pregnancy (9). Thus, within this unfavorable socioeconomic and obstetric context, the impact of food and nutritional insecurity (FNI) on pregnant women has become a focus of concern in French Guiana and stimulated efforts to correct this problem (10).

Since 2023, the population health intervention research project called “Nutri Pou Ti’Moun” (NPTM) has aimed to improve equity in nutritional health during pregnancy and early childhood (11). This project was initiated by healthcare providers and researchers at the Cayenne referral hospital and developed in close collaboration with community organizations, local partners, and government authorities. The project consisted of four phases (12): a baseline assessment (extent and severity of the problem, perceived needs, context), the development of a pilot intervention based on an intervention theory, its evaluation (implementation, effectiveness and mechanisms), and its dissemination (transfer and scaling up-currently underway).

Phase 1 of NPTM (2023), before the intervention, corresponded to a multicenter cross-sectional survey in maternity wards, with the primary objective of estimating the prevalence of FNI in French Guiana among a representative sample of pregnant women. This phase revealed that one in three pregnant women lived in a food-insecure household and that less than one in two pregnant women had achieved sufficient dietary diversity to meet their essential micronutrient needs (13). During this phase, a stakeholder mapping was conducted, along with profiling the women most vulnerable to FNI.

Following this regional diagnostic phase, Phase 2 of NPTM (2023–2024) consisted in designing, implementing and evaluating the effectiveness of a pilot nutritional health intervention that focused on nutrition during pregnancy. The intervention included several components: collective nutritional education, peer support, health mediation, distribution of food baskets, and a holistic approach to health. The primary expected effect was an improvement in dietary diversity among vulnerable pregnant

women. A process evaluation of the intervention, providing full description, underlying theories, and fidelity of implementation has already been published(14). The present article evaluates the effectiveness of this intervention in real-life conditions.

# Methods

# 1. NPTM nutritional health intervention

The NPTM intervention included the following five components and can therefore be considered a “complex” intervention (15): i/ Group sessions promoting health, including six nutrition-specific (e.g., dietary diversity and balance, dietary moderation and adequacy; hydration, hygiene practices, and prevention of iron deficiency/anaemia) and six multi-topic sessions (e.g., peer group cohesion, physical activity during pregnancy, managing a food budget, breastfeeding, self-esteem, prenatal care information), and one postpartum session (experience of childbirth and breastfeeding); ii/ Peer support approach: participants were invited to attend one prenatal session per week over 12 weeks with about ten other women. The same women participated throughout the program; iii/ Health mediation: each group of participants was accompanied by a health mediator who fostered group cohesion and co-facilitated the sessions with a topic specialist; All the health mediators spoke French, Guyanese Creole, and Haitian Creole. One mediator spoke one of the local languages (Aluku); iv/ Food baskets: consisting of fresh, local fruits, vegetables, condiments, and eggs, were distributed to each participant at the end of each nutrition session, for a total of 6 baskets over 12 weeks. Each basket cost 35 euros, and their size was not tailored to household size; v/ Mobile health (mHealth): creation of a mobile phone discussion group bringing together participants, health mediator, and dietitian. It provided session reminders, reinforced nutrition messages and encouraged sharing of meals prepared from the food baskets, and enabled Q&A sessions; vi/ Supplement to the standard ANC: this program did not focus on a specific disease. It also did not replace standard ANC.

The NPTM project was developed through close collaboration between the Cayenne University Hospital and the French Guiana Perinatal Network, with support from a wide range of local stakeholders, including healthcare providers from the regional authority’s mother and child care centers, local health associations, dietitians, sports instructors, and psychologists. The structure and content of the sessions were co-designed through a participatory approach that actively involved these stakeholders, including the session facilitators. At least one meeting per quarter was held to review the project's progress, discuss feasibility and acceptance, and maintain cohesion within the multidisciplinary team.

The theoretical framework for the complex intervention was developed following a review of the literature (underlying theoretical concepts and experiments in other contexts), data from regional studies on the subject, regional context data, and an experiential knowledge from stakeholders (14).

**2. Evaluation of the intervention’s effectiveness**

**Study sites.**

The study sites were located in four major cities in French Guiana (Cayenne, Rémire-Montjoly, Matoury, and Macouria).

# Study design

This study used a quasi-experimental design with a historical comparative group. Participants recruited between January to October 2023 received standard ANC (control group) and were compared to a separate cohort of women, recruited from October 2023 to August 2024, who received the intervention (intervention group).

## Study population and recruitment procedures

# For the control group:

Women were recruited during prenatal visits in the third trimester of their pregnancy (the methodology was previously published) (13). These women had received standard ANC (Fig. 1).

## For the intervention group:

Women were recruited during prenatal visits before the 22th week of gestation (WG), prior to the first session of the NPTM intervention (Fig. 1) (14).

Health care professionals invited the women to participate in the study. If a woman agreed to participate, a health mediator explained the study to her in detail (both verbally and in a written information sheet), after which she was enrolled and assigned to a group of women at the intervention sites. These sites were either primary care centers or locations situated near these centers.

## Data collection

After obtaining consent from the participants, a multilingual interviewer conducted face-to-face interviews to collect data. The questionnaire was administered in two phases (Fig. 1). The first phase unfolded during the third trimester of pregnancy at the time of enrollment for the control group and after the intervention for the intervention group. The second phase took place for the 2 groups, after delivery and before discharge from the maternity ward (three to five days of maternity stay).

*Data collected during* third trimester of pregnancy *included*:

- 24-hour qualitative food recall using a list of 24 pre-defined food groups.

*Data collected during the maternity stay included*:

- Sociodemographic data on the participant, including age, birth place, administrative status, length of stay in French Guiana, education level, universal health insurance, occupation, and social support as assessed by two questions from the French EPICES scale (Assessment of Precarity and Health Inequalities in Health Consultation Centers) (16).
- Data on the participant's household was also collected, including household composition.

The variables used and the corresponding questions from the questionnaire are available in an additional file (Additional file 1).

# Outcomes:

# Primary outcomes:

Our primary outcome was women's dietary diversity assessed in the third trimester of pregnancy using the Minimum Dietary Diversity for Women (MDD-W) and the Women's Dietary Diversity Score (WDDS) (17).

The MDD-W and WDDS are calculated based on a 24-hour dietary recall. Individual data on food intake are collected using a list of 24 predefined food groups (17).

Based on this recall, the women's dietary diversity score (WDDS-10) is defined as the number of different food groups consumed over the past 24 hours, according to the recommended classification into 10 food groups. The ten food groups are as follows: grains, roots, and tubers; legumes; nuts and seeds; dairy products; meat, poultry, and fish; eggs; dark green leafy vegetables and other vegetables; other fruits and vegetables rich in vitamin A; other vegetables; and other fruits. The responses for each food group were summed for each participant to obtain the WDDS, whose value ranges from 0 to 10.

The MDD-W indicator, on the other hand, is defined for a WDDS comprising at least 5 different food groups (out of the 10) and corresponds to adequate dietary diversity to meet the needs for 11 essential micronutrients in pregnant women(18).

*Secondary outcomes*:

- - The "All-5" score was defined as the proportion of women who had consumed the five food groups recommended daily in dietary guideline over the previous 24hs: at least one vegetable; at least one fruit; at least one pulse, nut or seed; at least one animal-sourced food; and at least one starchy food (19).
- - the "Unhealthy Food Consumption" (UFC), which had been calculated based on consumption over the previous 24 hours of the following four 3 groups: Salty or fried snacks; Sweet foods; Sweetened drinks (including juices, fizzy drinks and sweetened milk drinks)(20).

# Statistical Analysis

Statistical analysis was performed using STATA statistical software, version 19.0.

First, a comparison of socio-economic data between the control and intervention groups was conducted. A univariate and then bivariate analysis were performed with alpha set at 5%. For the cross-tabulation of categorical variables (independent samples), Pearson's chi-square test was used, as well as Fisher's exact non-parametric test if the theoretical sample sizes were less than 5.

Given the quasi-experimental design and the need to minimize potential confounding, a propensity score used to balance observed covariates between the two groups (21, 22). The propensity score represents the probability of having received the NPTM intervention and was estimated using logistic regression. To identify the covariates included in the propensity score model, a causal analysis based on a directed acyclic graph (DAG) was conducted. The DAG represented the assumed causal relationship between the intervention (exposure) and adequate dietary diversity (outcome), including variables associated with both the intervention and dietary diversity (23) (Additional file 2). The 9 measured covariates selected from the DAG and included in the propensity score model were: age group, place of birth, education level, employment situation, administrative status, length of stay in French Guiana, universal health insurance coverage, support from relatives (housing and/or financial support, based on the EPICES score), and household size.

We then estimated the average treatment effect on the treated (ATET), corresponding to the average effect of the NPTM intervention among women in the intervention group, using propensity score matching (PSM) (24). For the PSM analysis, 1:1 nearest-neighbor matching was performed, whereby each participant in the intervention group was matched to one participant in the control group based on the propensity score, using a caliper width of 0.2. Treatment effects after matching were estimated using conditional logistic regression models for MDD-W and mixed-effects linear regression models for WDDS.

Finally, covariate balance between the two groups before and after propensity score adjustment was assessed using the absolute standardized mean difference (SMD) for each covariate. An absolute SMD value < 0.1 was considered indicative of adequate balance, whereas a value > 0.2 indicated substantial imbalance (Additional file 3)(25). Balance plots were also examined (Additional file 4).

Finally, sensitivity analyses for unmeasured confounding were conducted using Rosenbaum's Mantel–Haenszel bounds applied to the propensity score-matched (PSM) sample (26). In addition, as a robustness analysis, inverse probability of treatment weighting (IPTW) was performed to assess whether the estimated treatment effect was consistent across different propensity score methods(24).

A significance level of 5% was used for all analyses.

# Ethical clearance

The "non-opposition" of all patients was obtained prior to their inclusion, as well as that of the legal representatives of minor patients. The study was approved by the Committee for the Protection of

Persons (CPP) and complies with the ethical principles of the 1964 Declaration of Helsinki for medical research involving human subjects.

## RESULTS

# Control and intervention groups

The control group was composed of women included in the 2023 NPTM survey in maternity wards (786 women in total). From this sample, 644 women were included in the control group after excluding those who were lost to follow-up, refused the interview, could not be interviewed due to a language barrier, or lacked data on their 24-hour dietary recall (used to measure the primary outcome) (Fig. 2).

The intervention group consisted of women who agreed to participate in the intervention and attended at least one group session as part of it (122 participants). From this sample, 101 participants were included in the intervention group after excluding those who were lost to follow-up, those whose fetuses had died, and those for whom data on the 24-hour dietary recall (used to measure the primary outcome) were missing (Fig. 2).

# Women's uptake of the intervention

Half of the women in the intervention group had participated in at least 8 of the 12 group sessions offered (interquartile range, IQR: 7–10). Among the women in the intervention group, 65.3% had participated in at least 5 of the 6 group sessions on nutrition during pregnancy and had received at least 5 of the 6 baskets of fresh fruits and vegetables provided. Nearly one in three women had attended all the group sessions on nutrition (31.7%).

The main reasons given for not participating in group sessions were as follows: health problems or fatigue, medical appointments, transportation difficulties, and internships or training.

# Socio-economic characteristics of women

Women from the intervention group were older, had a lower level of education, were more likely to be from Haiti, were more likely to be immigrants without a valid residence permit, had lived in French Guiana for a shorter period of time, and were more likely to lack universal health coverage than women from the control group (Table 1). They were also more likely to live in bigger households.

Table 1
Comparison of the main characteristics of women from the intervention (n = 101) and control groups (n = 644).

| | | Control group | Intervention group | |
|---|---|---|---|---|
| **Socio-demographic characteristics** | | **n (%)** | **n (%)** | **p** |
| Age (years) (N = 745) | < 20 | 60 (9.3) | 5 (5.0) | < 0.0001 |
| | 20–34 | 448 (69.6) | 55 (54.5) | |
| | ≥ 35 | 136 (21.1) | 41 (40.6) | |
| Level of education (N = 731) | Primary school or lower | 99 (15.4) | 38 (27.7) | < 0.0001 |
| | Secondary / higher education | 536 (83.2) | 58 (57.4) | |
| Birth place (N = 745) | Haiti | 159 (24.7) | 75 (74.3) | |
| | Suriname | 89 (13.8) | 10 (9.9) | < 0.0001 |
| | Other | 396 (61.5) | 16 (15.8) | |
| Administrative status (N = 689) | Born in France | 317 (53.5) | 6 (6.3) | < 0.0001 |
| | Born abroad, documented | 153 (25.8) | 40 (41.8) | |
| | Born abroad, undocumented | 123 (20.7) | 50 (52.1) | |
| Length of stay in French Guiana (years) (N = 722) | < 8 | 216 (34.5) | 47 (49.5) | < 0.0001 |
| | 8–21 | 177 (28.2) | 43 (45.3) | |
| | ≥ 21 | 234 (37.3) | 5 (5.3) | |
| Access to Healthcare | | | | |
| Universal health insurance (N = 715) | Yes | 431 (69.7) | 28 (28.9) | < 0.0001 |

| | | Control group | Intervention group | |
|---|---|---|---|---|
| **Socio-demographic characteristics** | | **n (%)** | **n (%)** | **p** |
| | No | 187 (30.3) | 69 (71.1) | |
| **Household composition** | | | | |
| Total number of people in the household (N = 698) | From 1 to 2 | 198 (32.9) | 17 (17.7) | 0.007 |
| | From 3 to 4 | 208 (34.6) | 36 (37.5) | |
| | ≥5 | 196 (32.6) | 43 (44.8) | |
| **Financial situation** | | | | |
| To be unemployed (N = 736) | Yes | 305 (47.7) | 61 (63.5) | 0.004 |
| | No | 335 (52.3) | 35 (36.5) | |
| **Aid received and precariousness** | | | | |
| Support from relatives (N = 745) | Yes | 502 (78.0) | 59 (58.4) | < 0.0001 |
| | No | 142 (22.0) | 42 (41.6) | |

# Dietary Diversity

In the control group, 54.0% [CI95%: 50.1–57.9] of women had MDD-W ≥ 5, compared to 73.3% and in the intervention group, 73.3% [CI95%: 63.5–81.6] ($p < 0.001$). The median MDD-W score for the control group was 4.7 [CI95%: 4.6–4.8] and 5.5 [CI95%: 5.2–5.9] for the intervention group, 5.5 [CI95%: 5.2–5.9] ($p < 0.001$).

**Figure 3.** *Comparisons of Dietary quality indicators (*Women Dietary Diversity Score (*WDDS)*, Unhealthy Food Consumption (UFC) and All-5) *in the control (n = 644) and intervention groups (n = 101)*

*<0.05 **<0.01 ***<0.001

The proportion of women who consumed cereals, tubers, roots, and plantains was the highest (96.1% in the control group versus 99.0% in the intervention group), followed by the proportion of women consuming meat and fish (89.4% in the control group versus 88.1% in the intervention group). In both groups, they accounted for a smaller share of nut consumption (9.9% in the control group versus 8.9% in

the intervention group) and egg consumption (24.2% in the control group versus 23.8% in the intervention group). The WDDS food groups for which there was a significantly higher percentage of female consumers in the intervention group than in the control group were other vitamin A-rich fruits and vegetables, pulses, and other vegetables (Fig. 3).

The UFC was 77.6% in the control group and 77.2% in the intervention group ($p = 0.933$). The All 5 indicator was 11.3% among women of the control group and 51.5% among women of the intervention group ($p < 0.001$). More than 60% of the women in both groups had consumed sugary drinks the day before the survey. The percentage of women in the intervention group was significantly lower than that in the control group with regard to the consumption of sweet foods.

# Average effect of the intervention on dietary diversity

According to the PSM analysis, the positive average effect of the intervention (ATET) on the WDDS was an increase of 1.44 food groups [95%CI: 0.926–1.951; $p < 0.001$] for women in the intervention group. Similarly, the average effect of the intervention on the MDD-W, was 35.0 percentage points [95%CI: 19.7–50.4; $p < 0.001$] in the intervention group.

The results of the estimation of the average effect of the intervention on dietary diversity (MDD-W, UFC, All-5) in the intervention group (ATET) are presented in Table 2 (PSM method).

Table 2
Effect of the intervention on dietary diversity among beneficiaries (ATET), as measured by the Minimum Dietary Diversity for Women (MDD-W), the Women Dietary Diversity Score (WDDS), the Unhealthy Food Consumption (UFC) and the All-5 using propensity score matching (PSM) model.

| **Outcomes** | **Control group (%) n = 91** | **Intervention group (%) n = 91** | **Coefficient** | **CI95%** | ***p*** |
|---|---|---|---|---|---|
| **MDD-W** | **50.0** | **75.6** | **0.350** | **0.197 ; 0.504** | **< 0.001** |
| Grains, roots and tubers | 96.5 | 98.8 | 0.028 | -0.028 ; 0.083 | 0.328 |
| Pulses | 34.9 | 62.8 | 0.268 | 0.106 ; 0.430 | 0.001 |
| Nuts and seeds | 9.3 | 10.5 | 0.019 | -0.078 ; 0.117 | 0.695 |
| Dairy | 52.3 | 53.5 | 0.044 | -0.110 ; 0.199 | 0.575 |
| Meat, poultry, fish | 87.2 | 86.0 | 0.039 | -0.097 ; 0.174 | 0.575 |
| Eggs | 17.4 | 24.4 | 0.143 | 0.026 ; 0.261 | 0.016 |
| Dark leafy greens and vegetables | 30.2 | 41.9 | 0.147 | -0.021 ; 0.315 | 0.086 |
| Other vitamin A-rich fruits and vegetables | 40.7 | 67.4 | 0.359 | 0.218 ; 0.501 | < 0.001 |
| Other vegetables | 38.4 | 63.9 | 0.306 | 0.155 ; 0.456 | < 0.001 |
| Other fruits | 52.3 | 54.6 | 0.084 | -0.073 ; 0.242 | 0.294 |
| **UFC** | **70.9** | **74.4** | **0.049** | **-0.098 ;0.195** | **0.516** |
| Fried salty snacks | 20.9 | 15.1 | -0.017 | -0.136 ; 0.101 | 0.771 |
| Sugary food | 27.9 | 20.9 | -0.024 | -0.165 ; 0.117 | 0.741 |
| Sugary drinks | 60.5 | 58.1 | -0.027 | -0.198 ; 0.144 | 0.756 |
| **All-5** | **10.5** | **51.2** | **0.447** | **0.337 ; 0.556** | **< 0.001** |
| One starchy food | 96.5 | 98.8 | 0.028 | -0.028 ; 0.083 | 0.328 |

| Outcomes | Control group (%) n = 91 | Intervention group (%) n = 91 | Coefficient | CI95% | *p* |
|---|---|---|---|---|---|
| **MDD-W** | **50.0** | **75.6** | **0.350** | **0.197 ; 0.504** | **< 0.001** |
| One animal-sourced food | 93.0 | 95.3 | 0.092 | -0.026 ; 0.209 | 0.126 |
| One pulse, nut or seed | 37.2 | 65.1 | 0.285 | 0.124 ; 0.446 | 0.001 |
| One vegetable | 55.8 | 83.7 | 0.326 | 0.177 ; 0.475 | < 0.001 |
| One fruit | 57.0 | 82.6 | 0.365 | 0.216 ; 0.514 | < 0.001 |

In addition to the MDD-W indicator, the PSM analysis (Table 2) were used to estimate the average effect of the intervention on the percentage of women who had consumed specific food groups the previous day: for fruits or vegetables rich in vitamin A, for other plant-based foods (excluding those rich in vitamin A and dark green leafy vegetables); for pulses; and for eggs. Another ATET result showing a statistically significant improvement is the All-5 indicator.

However, the intervention had no significant association with the Unhealthy Foods Consumption UFC indicator.

## Sensitivity analysis and robustness

A Rosenbaum sensitivity analysis showed that the intervention effect remained statistically significant up to Γ = 1.7 (p = 0.048), but became non-significant at Γ = 1.8 (p = 0.069), suggesting moderate robustness to potential hidden bias (Additional file 5).

According to the analysis, the average WDDS was 1.01 point higher [95%CI: 0.51–1.50] among pregnant women who received the intervention, compared to the average score of 4.6 if none had participated in the intervention. Similarly, the average effect of the intervention on the MDD-W was by the IPTW analysis 23.3 percentage points [95%CI: 10.9–35.6: p < 0.001] in the intervention group by the IPTW analysis.

Furthermore, significant ATET were found for the same food groups in the subgroup analysis using both the IPTW and PSM approaches, with the exception of the ATET for the proportion of women consuming eggs. In fact, there was no positive average effect of the intervention on egg consumers who participated in the intervention, with a non-significant ATET (Additional file 6).

# DISCUSSION

## Key findings

This study highlights that participating in the “Nutri Pou Ti'moun” (NPTM) intervention was associated with greater dietary diversity among pregnant women in French Guiana. After propensity score matching, the estimated average intervention effects (ATET) was 35.0 percentage points [95%CI: 19.7–50.4] for achieving adequate dietary diversity during the third trimester of pregnancy (MDD-W ≥ 5) and + 1.44 food groups [95%CI: 0.92; 1.95] for the dietary diversity score (WDDS). The food groups that contributed most to this difference were vitamin A-rich fruits and vegetables, other vegetables, pulses, and eggs. However, no decrease in the number of women consuming sugary drinks or foods high in fat and sugar was observed.

Women in the intervention group had a marked multidimensional vulnerability profile, corresponding to the intervention’s target profile. They were more likely to be immigrants, have lower levels of education, lack universal health coverage, were more likely to be socially isolated, and to face unfavorable financial situations. The intervention also showed good acceptability and engagement, with 50% attending at least 8 out of 12 sessions and 65.3% had participated in at least 5 of the 6 group sessions on nutrition.

# Comparison of intervention effectiveness on MDD-W

Few studies have evaluated interventions aimed at improving the dietary diversity of pregnant women using either the MDD-W or the WDDS indicators(27–31). To our knowledge, no published studies from Latin America and the Caribbean have specifically addressed this question. Because the prenatal period is a critical window for maternal and child nutrition, pilot interventions should be evaluated before scaling up. In this context, the NPTM intervention was implemented and evaluated in French Guiana (14, 32).

Thus, our estimated intervention effect on dietary diversity during pregnancy is consistent with the positive effects reported in the literature, although the effect sizes vary across studies. In Ethiopia, a meta-analysis reported a significant increase in dietary diversity across eight studies(27), and positive effects were also reported in Bangladesh (28), Malawi (29), and Sri Lanka (30),whereas a study in India found a smaller, non-significant effect (31).

However, many included nutrition educations delivered during group or community sessions in addition to routine ANC, (27–31, 33, 34) while others incorporate brochures(35), mobile phone components (30), agricultural support (36, 37), financial support(34), or cooking demonstrations (33) to address the various pillars of food insecurity (food availability, access, and utilization). The NPTM intervention, meanwhile, stands out for its combination of components grounded in social cognitive theory (38). It included peer-led group sessions facilitated by community health mediators, supplemented by food support. This structure may have strengthened participants’ engagement, learning through observation and sharing experiences, and self-efficacy. These features, together with the relatively high frequency of sessions over 3 months, may also have contributed to the observed effect on the dietary diversity (27).

While the socioeconomic contexts of the intervention evaluations corresponded to low-income areas(27, 28, 30, 31, 33), the specific characteristics of the food environment may also explain the varying results

across studies. In French Guiana, difficulties in accessing a healthy and varied diet among some pregnant women often reflected their low socioeconomic status (13). The heavy reliance on imports from mainland France and local family farming with modest yields prevent French Guiana from achieving food self-sufficiency and result in very high food prices and difficulties in accessing food for poorer populations(5, 39). While ANC in French Guiana is theoretically accessible to all (with or without universal health coverage), social health inequalities persist (40, 41). Supplementary programs such as NPTM intervention aim to address certain needs — particularly in terms of nutritional health (education, support, care, etc.) — not covered by existing systems, based on the principle of proportionate universalism(42, 43). Interventions that specifically target the most disadvantaged subgroups of the population have shown greater effectiveness in reducing social inequalities in nutritional health than interventions targeting the entire population (44).

Beyond the average positive effect on the MDD-W or WDDS indicators, the estimated effects nutritional interventions varied by food group, reflecting differences in dietary habits and food environments across study contexts. Associations similar to those observed in our study were found between participation in the intervention and an increase in the number of women consuming vegetables other than those rich in vitamin A and dark green vegetables(31, 34), legumes(28, 34), and eggs(28). Contrary to what has been observed in other contexts(28, 29, 31, 34, 45), the intervention in French Guiana was not associated with a higher number of women consuming meat during pregnancy (already widely consumed in both groups) or nuts, seeds, and dairy products, which are very expensive and less culturally consumed in French Guiana. Furthermore, the food baskets distributed as part of the intervention could not, on their own, explain the improvement in dietary diversity, as the quantity and frequency of distribution (every 15 days) were insufficient to meet all the needs of pregnant women. Additionally, the 24-hour recall questionnaire was carried out long after the last basket was received by most women. The food groups that contributed most to the positive effect also corresponded to more affordable products, locally produced or home-grow and commonly consumed in French Guiana, particularly among pregnant women (carrot juice, pumpkin-based dishes, mangoes from gardens, beans or lentils in Caribbean Creole dishes, local eggs...).

While the intervention was associated with a higher proportion of women consuming healthy foods (among the 10 groups of WDDS), it does not appear to have reduced the proportion of women consuming unhealthy foods during pregnancy. The concepts of craving, pleasure, and addiction (particularly to sugary foods) may constitute socio-emotional factors that promote the consumption of unhealthy foods, potentially amplified by prenatal stress (46, 47). Sweeter and fattier foods, as well as fast food, may also be quicker to prepare and more popular with the rest of the family, particularly children (48). To help pregnant women moderate their consumption of unhealthy foods, nutrition education sessions could be offered to other household members, especially co-parents and children (37, 49). Additionally, although the intervention was grounded in behavioral theory, it was not specifically designed to target this particular behavior. Therefore, identifying the determinants of the consumption of specific unhealthy foods, such as sugar-sweetened beverages, and ensuring that appropriate behavior

change methods are translated into adequate practical applications may help improve intervention effectiveness.

## Strengths and limitations of the NPTM study

Initially, a cluster-randomized controlled trial was considered for this study but was ultimately ruled out due to the high risk of contamination. Ethical concerns were also raised regarding the lack of preventive measures for these particularly vulnerable women. Nevertheless, propensity score matching allowed for the control of potential confounding factors, even though it did not fully replace randomization(21, 24). The utility and effectiveness of this analytical method have been demonstrated for estimating the effect of a public health intervention, while distinguishing itself from experimental methods (50). The risk of potential hidden bias in this study was assessed using a sensitivity analysis, which estimated it to be moderate. Furthermore, the quality of the matching model used was confirmed by an assessment of covariate balance (SMD < 0.20). Analyses using the propensity score may also have been limited by the sample size of the intervention group.

The MDD-W is a reliable, rapid, standardized tool that has been validated in numerous contexts (such as pregnancy and among adolescents) and in many countries, notably in Latin America (18, 51, 52). However, because the data are self-reported, consumption of certain food groups may have been underestimated or overestimated due to social desirability bias. Furthermore, this is a qualitative indicator of dietary diversity that does not allow for quantitative measurement or an assessment of the nutritional quality of foods within the same food group (53). A more quantitative rather than qualitative approach could have helped identify differences in terms of portion sizes or quantities, or intra-group diversity (for the 10 WDDS groups as well as for sugary drinks or products high in sugar and fat).

# CONCLUSIONS

This quasi-experimental study showed that participation in the “Nutri Pou Ti’moun” pilot intervention, based on social cognitive theory, was associated with greater dietary diversity among pregnant women in socioeconomically vulnerable situations in French Guiana. Two important findings emerged from this real-world effectiveness evaluation: 1) an increase in the number of women consuming essential micronutrient-rich foods that are locally accessible and affordable, suggesting these behaviors may be sustained; and 2) high adherence among the target population, indicating that the intervention met their needs.

Areas for improvement during future scale-up could include: 1) the development of family-based approaches involving children and co-parents, particularly to help reduce the consumption of sugary drinks and foods high in sugar and fat; 2) the selection of behavior change methods that correspond to identified determinants and are appropriately translated into practical applications;

Beyond these encouraging findings, further research is needed to assess the long-term maintenance of dietary diversity effects and to evaluate implementation processes and scalability Indeed, this would be

useful in identifying the barriers to and facilitators of region-wide dissemination, as well as the mechanisms of effectiveness, to ensure transferability.

Nevertheless, this pilot study provides important data supporting interventions aimed at promoting nutritional health equity during the critical period of the first 1,000 days, particularly in settings characterized by social inequalities, food insecurity, and cultural diversity, such as French Guiana.

## Abbreviations

| | |
|---|---|
| ANC | Antenatal Care |
| ATET | Average Treatment Effect on the Treated |
| CI95% | 95% Confidence Interval |
| CPP | Committee for the Protection of Persons |
| DAG | Directed Acyclic Graph |
| DOHaD | Developmental Origins of Health and Disease |
| EPICES | Evaluation of Deprivation and Health Inequalities in Health Examination Centers |
| FAO | Food and Agriculture Organization of the United Nations |
| FNI | Food and Nutritional Insecurity |
| GDP | Gross Domestic Product |
| IPTW | Inverse Probability of Treatment Weighting |
| IQR | Interquartile Range |
| MDD-W | Minimum Dietary Diversity for Women |
| mHealth | Mobile Health |
| NPTM | Nutri Pou Ti'Moun |
| PSM | Propensity Score Matching |
| SMD | Standardized Mean Difference |
| UFC | Unhealthy Food Consumption |
| WDDS | Women's Dietary Diversity Score |

| | |
|---|---|
| WDDS-10 | Women's Dietary Diversity Score based on 10 food groups |
| WG | Weeks of Gestation |

# Declarations

### Ethics approval and consent to participate

All subjects and their legal representatives (if they were under 18) provided informed consent before recruitment. The study was approved by the French ethics committee of Saint-Etienne, France (“Comité de Protection des Personnes Sud-Est 1. CHU de Saint Etienne, 25 Boulevard Pasteur; 42 055 Saint Etienne. France”) on September 20, 2023 (ID-RCB number: 2023-A01739-36); This study adheres to the ethical guidelines of the World Medical Association Declaration of Helsinki—Ethical Principles for Medical Research Involving Human Subjects.

### Consent for publication

Not applicable

### Competing interests

The authors declare no competing interests.

### Availability of data and materials

The data sets used and/or analyzed in this study are available from the corresponding author upon reasonable request, subject to the approval of the French ethics committees.

### Authors’ contributions

MSG, CB and CG conceptualised the study, OD conceptualised the external evaluation, NT and

MSG implemented the study, MSG and CB analysed the data, MSG, CB, CG, OD, AD and MN

contributed to interpretation and MSG drafted the manuscript.

All authors read and approved the final version of the manuscript**.**

### Funding

This study received public funding from the “Agence Régionale de Santé de Guyane” ARS (French Guiana Regional Health Agency), the “Centre Hospitalier Universitaire de Guyane”, the “Dispositif Spécifique Régional de Périnatalité Guyane”, the “Direction Générale de la Cohésion et des Populations” DGCOPOP (programme “Mieux manger pour tous”) and the “Préfecture de Guyane”.

**Acknowledgements:**

Thank you to the participants for agreeing to take part in the study; thank you to the health mediators for their work: Roseline Etienne, Jeanie Deshommes, Sabine Ayaite, Ruth Alphonse, Yslande Buissereth, Guerline Jean, Guerda Louis, Jovany Macintosh, Miracle Samuel. Thank you to the members of the research support team: William Faurous, Sonia Martin, Linda Matignon, Mayka Mergay-Fabre, Christelle Elfort, Estelle Thomas, Sébastien Rabier; as well as close partners : Vanessa Izeros, Émeline Monjardé, Jean-Luc Bauza, the PMI teams (particularly : Dr Cathy Venturin, Paola Romuald, Virginie Bresson, le Dr Mylene Lau-Pau, Rolande Dorocant, le Dr Marie-Noëlle Delor, le Dr Dominique Guillot, Gildas Bourgade, Sophie Rivat, Anne Désiré, Laura Letur, Fanny Levert Lamide), CCAS teams (particularly: Elisa Goupillier et Leone Agelas), the city teams : Matoury, Rémire-Montjoly, Macouria et Cayenne ; thank you to the support : ARS Guyane (particularly Dorothée Alexandre), la prefecture de Guyane (particularly: Francis Happe et Marion De-Falco) et la DGCOPOP. Particular thanks to direction of CHU de Guyane. Special thanks to Dr. Gabriel Carles, who has made significant contributions to research on maternal and child health in French Guiana.

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# Figures

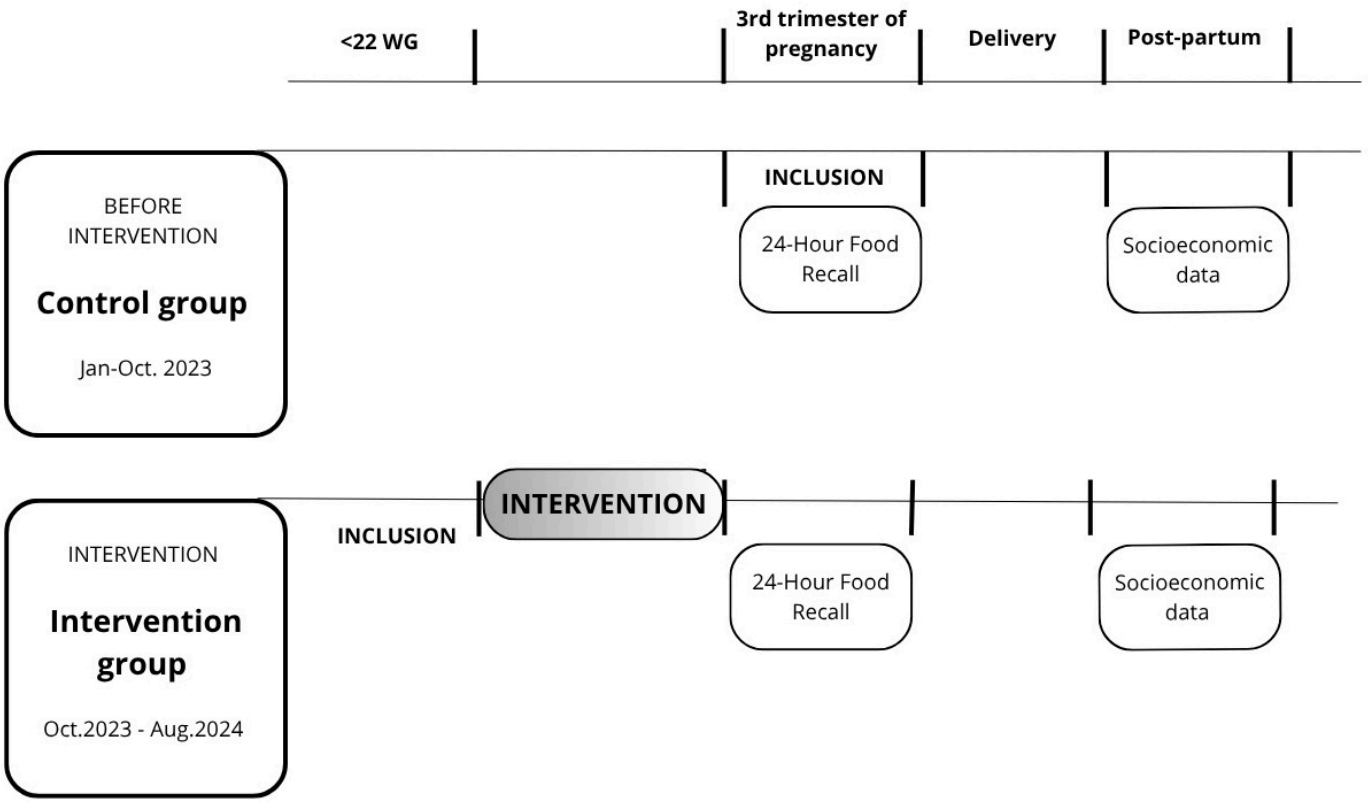
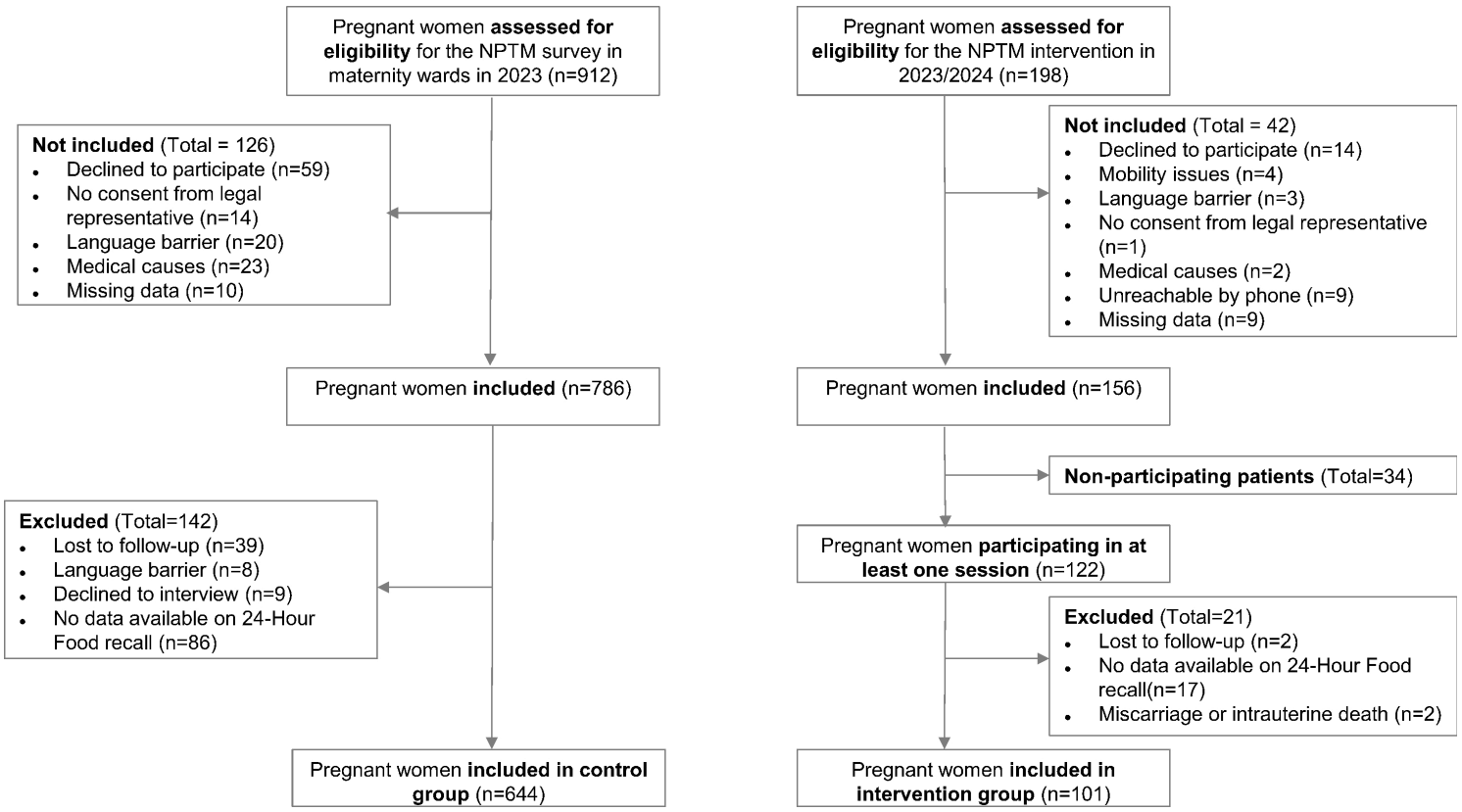



**Figure 1**

*Timeline of the Nutri Pou Ti'Moun NTPM study, featuring the intervention group and the control group, according to Dr Célia Basurko, 2025 (WG: weeks of gestation).*




## Figure 2

*Flowchart of the Nutri Pou Ti'moun (NPTM) study with control group and intervention group*

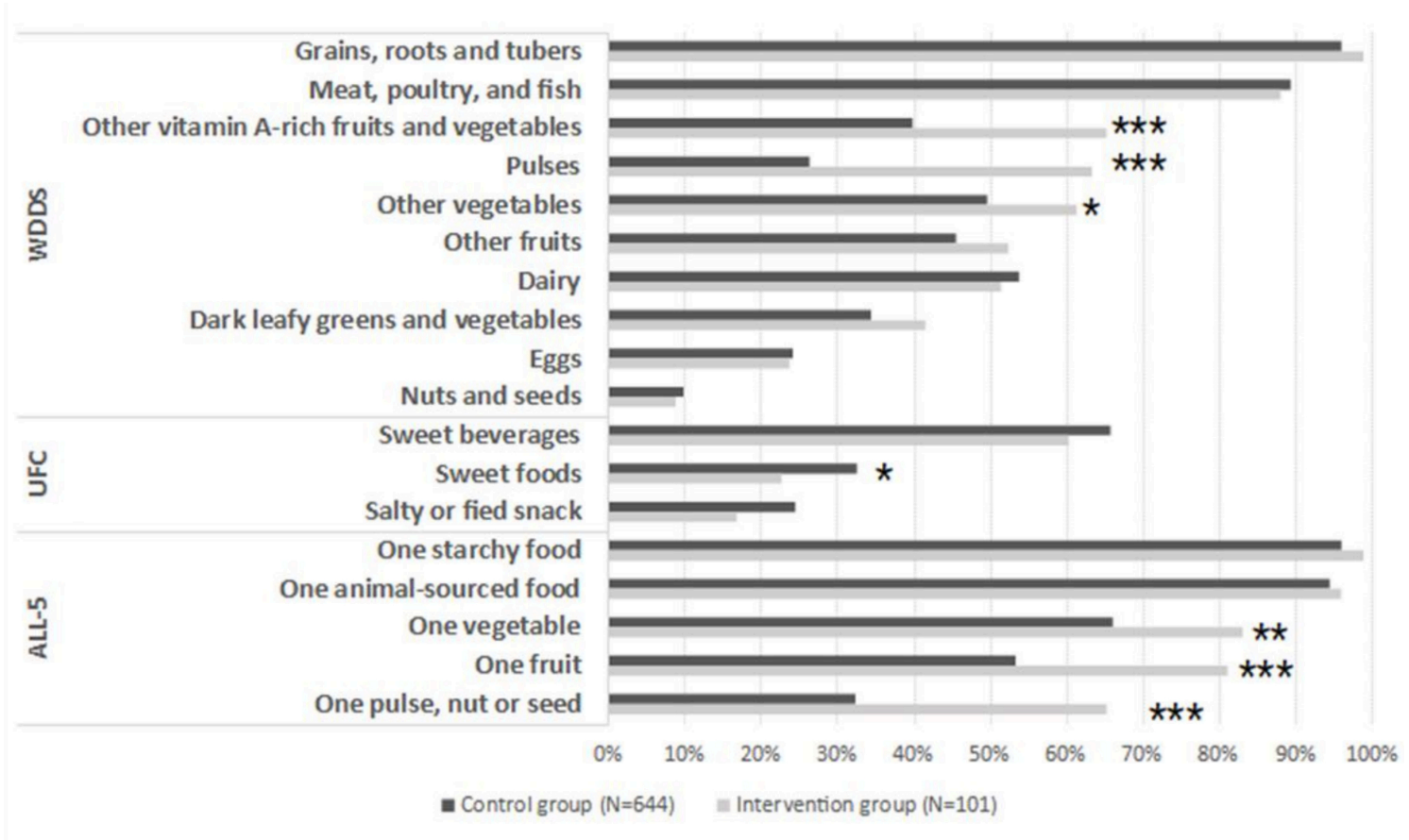


**Figure 3**

*Comparisons of Dietary quality indicators (*Women Dietary Diversity Score (*WDDS),* Unhealthy Food Consumption (UFC) and All-5) *in the control (n= 644) and intervention groups (n=101)*

# Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- ADDITIONALFILESlegends.docx
- Additionalfiles1.docx
- Additionalfiles2.docx
- Additionalfiles3.docx
- Additionalfiles4.docx
- Additionalfiles5.docx
- Additionalfiles6.docx