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# Shifts in dietary patterns and risk of type-2 diabetes in a Caribbean adult population: ways to address diabetes burden

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**Title page****Shifts in dietary patterns and risk of Type-2 Diabetes in a Caribbean adult population:  
ways to address diabetes burden****Running Title:** Diet changes and diabetes risk in the CaribbeanZoé Colombet<sup>1\*</sup> PhD, Pascal Leroy<sup>2</sup> Msc, Louis-Georges Soler<sup>2</sup> PhD, Caroline Méjean<sup>1</sup> PhD

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**Abbreviations**

BMI: body mass index

DASH: Dietary Approaches to Stop Hypertension

DQI-I: Diet Quality Index-International

mPNNS-GS: modified Programme National Nutrition Santé-Guideline Score

PNNS-GS2: Programme National Nutrition Santé-Guideline Score 2

PRIME: Preventable Risk Integrated ModEl

T2DM: type-2 diabetes mellitus

## 2 **Abstract**

3 **Purpose:** As the French West Indies are facing an ongoing nutrition transition with increasing  
4 type-2 diabetes mellitus (T2DM) prevalence, our study aimed to evaluate the effect of potential  
5 shifts in dietary patterns on T2DM risk in French West Indian adults according to several  
6 scenarios.

7 **Methods:** We used a cross-sectional multistage sampling survey on dietary intake conducted  
8 in 2013 on a representative sample of Guadeloupeans and Martinicans adults (n=1,063). From  
9 previously identified current dietary patterns, we used PRIME-Diabetes, a comparative risk  
10 assessment model, to estimate the effect of potential shifts from the “transitioning” pattern to  
11 the “convenient,” the “prudent,” and the “traditional” ones on T2DM risks.

12 **Results:** Potential shift in dietary intakes from the “transitioning” pattern to the “traditional”  
13 one reduced the T2DM risk in women (-16% [-22; -10]) and in men (-14% [-21; -7]), as the  
14 shift in dietary intakes toward the “prudent” pattern (-23% [-29; -17] and -19% [-23; -14],  
15 respectively). These risk reductions were mostly driven by increased whole grains, fruits, green  
16 leafy vegetable intakes, and decreases in potatoes, red meats, processed meats, and sugar-  
17 sweetened beverages. The shift in dietary intakes toward the “convenient” pattern did not affect  
18 the T2DM risks.

19 **Conclusion:** To curb the increase in T2DM prevalence and reduce this burden, one public  
20 health action could be to target transitioning adults and help them to shift towards a diet  
21 associated with a reduced risk of T2DM as a prudent or a traditional diet.

22 **Keywords:** French West Indies; dietary changes; PRIME; diabetes

24 **Text**

25 **Introduction**

26 Type-2 diabetes mellitus (T2DM) prevalence has increased rapidly in the Caribbean in the past  
27 decades becoming one of the leading causes of death (11% of total deaths) and premature  
28 disability and one of the most challenging public health issues [1–4]. Reported diabetes  
29 prevalence in the Caribbean steadily increased from 5% in the 1980s to 10% in 2014 [5, 6]. In  
30 addition, diabetes prevalence ranged from 11 to 18% in several English-speaking Caribbean  
31 countries [3]. In the French West Indies, the public National Information System for Health  
32 Insurance estimated an increase in prevalence of treated diabetes (age- and sex-standardised)  
33 from 7 to 9% between 2006 and 2015 in Guadeloupe and 7 to 8% in Martinique (4 to 5% in  
34 entire France), marking one of the largest increases in France [7, 8].

35 Dietary habits and sedentary lifestyles are the major factors of the rapidly rising incidence of  
36 T2DM among countries that have experienced fast nutrition transition [9, 10]. Briefly, the  
37 nutrition transition is schematically described as the transition from a traditional to a “Western”  
38 dietary pattern, generally characterised by high intakes of saturated fats, sugars, and refined  
39 foods and low intakes of fiber-rich foods, mainly owing to the high availability of cheap energy-  
40 dense, nutrient-poor foods [11]. There are few studies characterising the nutrition transition in  
41 the French West Indies. A recent study observes, over a relatively short period, changes  
42 consistent with the nutrition transition theoretical framework [12]. Another study, by the  
43 authors, highlighted four current coexisting dietary patterns reflecting different steps in dietary  
44 change as described in the nutritional transition literature [13]. These four dietary patterns were  
45 identified on the Kannari survey using a weighted principal component analysis (PCA) and a  
46 clustering procedure. First, a “traditional” pattern was identified with a high diet quality,  
47 characterized by high intakes of fruits, vegetables, tubers, fish, and traditional French West  
48 Indian dishes, and low intakes of red and processed meat, snacks, fast foods, and sweetened

49 beverages, mostly composed by women and older persons. Two globalised patterns were  
50 identified: a “prudent” pattern with a high diet quality and a “convenient” pattern with low diet  
51 quality. The “prudent” pattern, mostly composed by Guadeloupeans and by individuals living  
52 in a couple, is characterized by high intakes of fruits, vegetables, legumes, seafood and  
53 yoghurts, and low intakes of fatty and sweet products. The “convenient” pattern is characterized  
54 by high intakes of sweetened beverages, snacks, and fast foods, and is principally composed by  
55 young. Finally, a “transitioning” pattern was identified, which includes high intakes of  
56 traditional (tubers, legumes, fish) and “convenient” foods (bread, processed meat, sauces,  
57 sweetened beverages), resulting in intermediate diet quality. Given that this “transitioning”  
58 pattern is intermediate, composed by 27% of the population, mainly middle-aged individuals,  
59 we can hypothesise that this group of the population will change their diet in the coming years.  
60 These “transitioning” individuals may continue their nutrition transition toward a more  
61 globalised, less healthy diet (“convenient” pattern) or a healthier diet (“prudent” pattern), as  
62 predicted by the nutrition transition framework [11]. Alternatively, they may change towards a  
63 “traditional” pattern with the implementation of specific food policies. Indeed, as shown in a  
64 food market characterization study, there is currently an increasing trend for food choices based  
65 on more transparency and naturalness among the French West Indians, with a strong emphasis  
66 on local products and a real awareness of the link between food and health [14]. Also,  
67 strengthening local and traditional food production is an important issue with regard to multiple  
68 dimensions (food and nutrition security, ecologic, health, economic) as evidenced by it being  
69 part of the territorial food plans currently discussed by local institutions and as emphasized by  
70 the Guadeloupean food system diagnostic [15] conducted in 2019 by the French local  
71 administration with stakeholders. Our study, therefore, assumes that the French West Indian  
72 traditional diet is a realistic option if supported by the implementation of specific food policies.  
73 Furthermore, traditional diets such as the Mediterranean, Nordic, or Japanese diets, have been

74 largely described as protective against coronary heart diseases, cancers, diabetes, and obesity  
75 [16–18]. Promoting traditional diets and their integration into the local food system has been  
76 recently emphasized in international literature as a new avenue for more sustainable diets [18].  
77 Thus, actions from health and nutrition policies targeting these “transitioning” individuals may  
78 be a real lever to prevent a shift to a less healthy diet.

79 Simulation studies such as the Preventable Risk Integrated Model (PRIME), assess the  
80 population-level impact of different dietary intake scenarios on nutrition-related mortality[19].  
81 These simulations are essential for policy-makers as they provide useful estimates of the  
82 potential health-related gains from a given change [19]. PRIME-Diabetes allows us to estimate  
83 the variation in the T2DM risk related to dietary changes [20].

84 Using the PRIME-Diabetes model, we aimed to evaluate several scenarios to estimate the  
85 potential impact of shifts from the “transitioning” pattern toward another pattern on the T2DM  
86 risk in French West Indian adults, and to identify the foods that contribute the most to these  
87 changes of T2DM risk.

## 88 **Subjects and Methods**

### 89 Population

90 We used the cross-sectional Kannari survey conducted in 2013 in children ( $\geq 3$  years) and  
91 adults (16 to 95 years) of Martinique and Guadeloupe, two French regions. This is described  
92 in-full elsewhere [13, 21, 22]. Briefly, the Kannari survey, aimed to be representative, was  
93 based on multistage stratified random samples of the French West Indies populations to  
94 describe food intakes, health, and nutritional status. Sample selection was based on a three-  
95 stage cluster design (geographic areas, household, and individuals in the household), stratified  
96 by chlordecone contamination areas (coastline and inland). Among the 2,514 households

97 initially selected in Guadeloupe and 2,548 in Martinique, 1,671 and 1,616 were respectively  
98 included after excluding the ineligible or not reachable households (**Supplemental Figure 2**).  
99 To be eligible, the household needed to be resident in the French West Indies for at least six  
100 months, to continue residing in the French West Indies during the three months following first  
101 contact, and the individuals needed to reside in the household at least four days a week and able  
102 to complete the survey. Of the contacted and eligible households, 880 participated in  
103 Guadeloupe and 919 in Martinique [21]. The household participation rate was thus 52.7% in  
104 Guadeloupe and 56.9% in Martinique. Among the participating households, 668 adults in  
105 Guadeloupe and 673 in Martinique responded to at least one 24-hour recall, representing  
106 individual participation rates of 75.9 % and 73.2%, respectively. For the present analysis, we  
107 only used adults aged 25 years old or over as it was the minimum age available from the adult  
108 population data used (i.e., 25-34 years old was the first bracket to be totally adult, the previous  
109 one being 15-24 years old).

110 The Kannari survey respected the Declaration of Helsinki guidelines and received approval  
111 from the French Data Protection Authority (N°05-1170) and an ethical research committee  
112 (CPP N°2-13-10). Written informed consent was obtained from all participants.

### 113 Data collection

114 Questionnaires collecting demographic and socioeconomic characteristics and health status  
115 were administered at home through face-to-face interviews. Anthropometric data were  
116 measured by trained interviewers with both French and Creole language skills. For this analysis,  
117 socioeconomic indicators were education, employment status, and being a recipient or not of  
118 social assistance benefits. Demographic characteristics were sex, age, location (Guadeloupe or  
119 Martinique), single-parent household, presence or not of at least one child in the household. We  
120 also used the weight and the height, both measured at participants' homes. Body mass index



121 (BMI) was calculated and categorized according to the World Health Organization (WHO)  
122 classification [23] and recoded into three categories: underweight ( $BMI < 18.5$ ) or normal weight  
123 ( $18.5 \leq BMI < 25.0$ ), overweight and obese ( $BMI \geq 25.0$ ).

124 Dietary data were collected by phone using two non-consecutive randomly assigned 24-hour  
125 recalls conducted by trained dietitians. Participants were asked to describe detailed dietary  
126 intake and quantities consumed during the 24 hours preceding the interview. Portion sizes were  
127 estimated using standard measurements (e.g. home containers, grams indicated on the package)  
128 or a validated illustrated booklet [24], representing more than 250 foods specific to the French  
129 West Indies (corresponding to 1000 generic foods) served in seven different portion sizes.  
130 Values for energy, macronutrients and micronutrients were estimated using published nutrient  
131 databases [25] and were extended for French West Indian market foods and recipes. In addition  
132 to the 24-hour recalls, participants completed a food frequency questionnaire (FFQ) during  
133 face-to-face interviews about their usual frequency of consumption of 119 food and beverage  
134 groups over the 12 last months. Then, we used the Multiple Source Method [26] to estimate  
135 usual dietary intake using the amounts of consumption from 24-h recalls combined with  
136 consumption frequencies from the FFQ, as described elsewhere [13, 22].

137 We identified and excluded energy under-reporters using the method proposed by Black [27].  
138 However, unlike Black, we used Mifflin equations [28] to estimate the basal metabolic rate  
139 (BMR) since a high prevalence of overweight and obesity was observed in our study sample.  
140 BMR was compared to energy intake, taking into account a physical activity level of 1.55 as  
141 recommended by Black [27], the WHO value for 'light' activity. Subjects who reported specific  
142 conditions that could objectively explain low energy intake, such as a low-energy diet to lose  
143 weight or acute disease, were not recorded as underreporters.

144 The dietary intake estimations used specific survey procedures to consider weighting and  
145 stratification to consider the complex survey design (i.e., `procsurveymeans` in the SAS software)  
146 and to be representative of the French West Indian populations [13].

147

#### 148 Dietary patterns

149 The four dietary patterns used in the present analysis were identified and detailed in a previous  
150 study on the Kannari survey, led by our team [13]. The dietary patterns in the French West  
151 Indian population were identified using a two-step method: a principal component analysis  
152 (PCA) on food group intakes followed by a clustering procedure, as detailed elsewhere [29,  
153 30]. The PCA was used as a dimension-reduction technique to reduce the initial range of  
154 information by maximising variance. Next, the clustering procedure using the dimensions  
155 retained in the PCA enables the grouping of the participants into homogeneous, non-  
156 overlapping groups based on their similarities in a particular set of variables [29]. In this  
157 analysis, clustering results in grouped subjects in a similar pattern of mean food intake. Thus,  
158 each cluster can then be qualified as a dietary pattern.

159 We first applied a weighted PCA on food group intakes (in grams per day) adjusted for daily  
160 energy intake according to sex [13]. We used the residual method to adjust for daily energy  
161 intake, which allows us to estimate differences in intakes not driven by differences in energy  
162 intake. To be representative of the French West Indian population, the PCA was weighted using  
163 the Kannari survey weights calculated for each sex on age, education, marital status, birthplace,  
164 presence of at least one child in the household, living in an area with chlordecone contamination  
165 (coastline and inland) and urban size as previously described [13]. Food groups with a factor  
166 loading coefficient under 0.25 were excluded. The PCA was applied to the 25 food group  
167 intakes among 39 available (Fruits; Vegetables; Bread and rusk; Potato; Tubers (other than  
168 potatoes); Pasta; Rice; Semolina and other cereals; Legume; Whole-grain products; Fishes;

169 Seafoods; Red meats; Poultry; Processed meats; Offal; Yogurts; Salad dressing and sauces;  
170 Butter; Snacks and fast foods; Biscuits, cakes and pastries; Fatty and sweet products (e.g.,  
171 chocolate, ice cream); Non-alcoholic and non-sweetened beverages (e.g., water, coffee, tea);  
172 Sweetened beverages and juices; and Alcoholic beverages).

173 PCA generates independent linear combinations of the initial food group variables, maximizing  
174 the explained variance. Factors were rotated by an orthogonal transformation. According to  
175 eigenvalues above 1.5, Scree test (Cattell test) and interpretability of factors, three dimensions  
176 were retained [13].

177 Next, we performed a clustering procedure on these three dimensions using Ward's hierarchical  
178 classification of the individuals, maximizing the inter-class inertia. The graphical observation  
179 of the dendrogram, illustrating stages of classification, pseudo-F, pseudo-t<sup>2</sup>, and the cubic  
180 clustering criterion (CCC) was used to estimate the appropriate number of clusters [13]. After  
181 cluster stabilization was carried out to distribute the individuals better by clusters, we evaluated  
182 the robustness of the classification using kappa coefficients, markers of agreement between  
183 each simulated sample, and the whole sample, calculated for 50 randomly selected samples  
184 composed of three-quarters of the whole sample, using an equal probability sampling method  
185 [13].

186 This cluster analysis yielded groups interpreted as dietary patterns and labelled according to  
187 their main food intakes.

## 188 Statistical analysis

### 189 *Estimating the risk of Type-2 Diabetes*

190 We evaluated the potential impact of dietary pattern substitution on the T2DM risk using a  
191 model structurally similar to the Preventable Risk Integrated Model (PRIME) [19] as developed

192 by Adjibade *et al.* [20]. PRIME is a comparative risk assessment model designed to estimate  
193 the impact of changes in the age- and sex-specific distribution of one or more of twelve  
194 behavioural risk factors of non-communicable diseases mortality. This risk factors were direct  
195 associations or mediating factors that include body mass index (BMI), blood pressure and blood  
196 cholesterol [19]. Briefly, PRIME estimates the change in the annual number of deaths between  
197 the baseline and counterfactual scenarios that depends on changes in the distribution of  
198 behavioural risk factors in the study population. Based on the same principle Adjibade *et al.*  
199 developed PRIME-Diabetes, a model estimating the variation in T2DM risk related to lifestyle  
200 changes [20]. As originally reported [19], risk relationships were drawn from published meta-  
201 analyses and included parameters appropriately adjusted for other behavioural risk factors to  
202 minimize the risk of double-counting of effect size.

203 PRIME-Diabetes was set up using relative risk data on the dose-response associations between  
204 the T2DM risk and each food group or nutrient identified as having an impact on the risk of  
205 T2DM: whole grains, refined grains, fruits, green leafy vegetables, other vegetables, nuts,  
206 potatoes, dairy products, red meats, processed meats, butter, fish, eggs, olive oil, tea, coffee,  
207 chocolate, sugar-sweetened beverages, daily energy, carbohydrates, magnesium [20]  
208 (**Supplementary Figure 1**). Additionally, change in energy intake is an important factor for  
209 T2DM risk estimates as energy imbalance is associated with being overweight, itself associated  
210 with the T2DM risk [20]. Thus, the model was parameterized so that a change in energy intake  
211 resulted in a change in the T2DM risk as a function of the BMI and the level of physical activity  
212 of the participants [20]. As the information on physical activity was not available for our study,  
213 an average level of physical activity was defined making it constant. Also, we did not include  
214 alcohol intake in our analyses as alcohol intake is highly under-reported in our sample.

215 To summarise, within PRIME-Diabetes, diet can impact T2DM risk through two distinct  
216 pathways as shown in **Supplementary Figure 1**: (1) through food group and nutrients intakes  
217 directly, independently of the energy intake, (referred as dietary effect), and (2) through energy  
218 intake and BMI.

### 219 *Dietary patterns substitution scenarios*

220 Based on the four coexisting dietary patterns previously identified (prudent, traditional,  
221 convenient and transitioning) [13], we have evaluated the changes in the T2DM risks for three  
222 counterfactual scenarios. The “transitioning” pattern was considered as the baseline situation  
223 as it was characterised by both high intakes of traditional and “modern” foods, resulting in  
224 intermediate diet quality. Furthermore, the “transitioning” pattern was mainly composed by  
225 middle-aged individuals. We hypothesised that the “transitioning” pattern group may shift  
226 towards a traditional diet or may, by continuing the nutrition transition, shift toward a more  
227 globalised diet. Thus, we estimated changes in the T2DM risks replacing the “transitioning”  
228 pattern by another pattern. We ask what if the “transitioning” group shifted instead towards (i)  
229 the “traditional” pattern; (ii) the “prudent” pattern; or (iii) the “convenient” pattern. The food  
230 group consumption and nutrient intakes were the means for each dietary pattern of each food  
231 group and nutrient included in PRIME-Diabetes. Note that our analyses are only based on the  
232 food intakes of the patterns; this means that the change in risk of diabetes is only due to the  
233 change in dietary intake, based on initial intakes of each dietary pattern, independently of  
234 individual characteristics.

235 Changes in the T2DM risk were expressed as percentages. Monte Carlo simulations (100,000  
236 iterations) were performed to estimate 95% uncertainty intervals around the results. Given that  
237 age was highly associated with the dietary patterns and BMI is strongly associated with the

238 T2DM risk, the dietary intake estimations added into the PRIME-Diabetes were adjusted for  
239 age and BMI.

240 The PRIME model algorithm was implemented in R. All other data management and statistical  
241 analyses were conducted using SAS (version 9.4; SAS Institute Inc., Cary, NC, USA).

## 242 **Results**

243 Among the 1,799 adults ( $\geq 16$  years) enrolled in the Kannari survey, 1,341 had at least one 24-  
244 hour dietary recall (**Supplemental Figure 2**). We excluded 96 adults aged under 25 and 182  
245 energy under-reporters, leaving 1,063 participants included in the analyses.

246 The participants were categorized according to their dietary patterns into “transitioning”,  
247 “traditional”, “prudent”, and “convenient” patterns, representing respectively, 27, 27, 24, and  
248 22% of the sample. **Supplementary Table 1** details the daily intake of nutritional components  
249 included in the PRIME-Diabetes model of each dietary pattern. **Supplementary Table 2**  
250 describes the demographic and socioeconomic characteristics associated with these patterns.

251 **Table 1** describes the modelled changes in T2DM risk if subjects shifted from one pattern to  
252 another and the **Figures 1, 2** and **3** show the contribution of each nutritional component  
253 included in the PRIME-Diabetes model to these changes in T2DM risk.

### 254 From the “transitioning” to the “traditional” pattern

255 The shift from the “transitioning” pattern to “traditional” decreased the T2DM risk significantly  
256 both by changes in dietary intake and a decrease of the mean BMI due to a decrease in energy  
257 intake, mainly in women (**Table 1**). The change in dietary intake is estimated to result in the  
258 highest change in the T2DM risk: -16.0 [-22.0; -9.6] in women and -14.2 [-20.7; -7.0] in men  
259 (**Table 1**). In particular, the increase in consumption of whole grains, fruits, green leafy

260 vegetables, olive oil (only in women), tea, and magnesium (only in men) and the decrease in  
261 consumption of potatoes, red meat, processed meats, sweetened beverages, mainly contribute  
262 to the estimated decrease in the T2DM risk whereas the decrease in the intake of coffee, butter,  
263 and magnesium (only in women) increased the T2DM risk (**Figure 1**).

#### 264 From the “transitioning” to the “prudent” pattern

265 The shift from the “transitioning” pattern to “prudent” decreased the T2DM risk due to changes  
266 in dietary intake, and more widely for women (-23.0 [-28.7; -16.9]) than for men (-19.0 [-23.3;  
267 -14.4]), but not through a significant change in the BMI due to shifting in energy intake (**Table**  
268 **1**). The increase in the consumption of whole grains, fruits, green leafy vegetables, olive oil  
269 (only in women), tea, and magnesium, and the decrease in consumption of potatoes, red meat  
270 (only in men), processed meats, and sweetened beverages contributed to reducing the T2DM  
271 risk whereas the decrease in the intake of coffee, butter, and olive oil (only in men) increased  
272 the T2DM risk (**Figure 2**).

#### 273 From the “transitioning” to the “convenient” pattern

274 The shift from the “transitioning” pattern to “convenient” increased the T2DM risk in men  
275 through the effect of energy intake on T2DM risk through the BMI (3.4 [2.5; 4.3]): the slight  
276 increase in the energy intake increased the mean BMI. While the overall food intake changes  
277 from the “transitioning” to the “convenient” pattern did not significantly change the T2DM risk,  
278 some dietary changes have impacted the T2DM risk opposingly (**Figure 3**). Indeed, the  
279 estimated decrease in the intakes of fruits, vegetables (except green leafy ones), coffee, butter,  
280 and magnesium and the estimated increase of sweetened beverages intakes (only in men)  
281 increase the T2DM risk. On the contrary, the estimated increase in consumption of whole  
282 grains, tea, green leafy vegetables (only in women), and olive oil (only in women) and the

283 decrease in consumption of potatoes, red and processed meats, and sweetened beverages (only  
284 in women) reduced the T2DM risk.

## 285 **Discussion**

286 The present study found that shifting from the “transitioning” pattern to a “prudent” pattern was  
287 the changing scenario that could reduce the most T2DM risks, especially among women. To a  
288 lesser extent, shifting to a “traditional” pattern could also reduce T2DM risks. The reduction in  
289 T2DM risk was specifically driven by increases in consumption of whole grains, fruits, and  
290 green leafy vegetables, and decreases in consumption of potatoes, red meats, processed meats,  
291 and sugar-sweetened beverages. Unexpectedly, shifting toward the “convenient” pattern did not  
292 change the T2DM risks. Indeed, the increase in T2DM risk due to the decrease in the intake of  
293 fruits, vegetables (except green leafy ones), coffee, butter, and magnesium was counterbalanced  
294 by the increase in consumption of whole grains, tea, green leafy vegetables (only in women)  
295 and olive oil (only in women) and the decrease in consumption of potatoes, red meats, and  
296 processed meats.

297 In this study, the effect of energy intake on T2DM risk through the BMI was significant in  
298 participants shifting from the “transitioning” pattern to a “traditional” one, particularly in  
299 women. This means that a decrease in energy intake decreased the T2DM risk through a  
300 decreased BMI. Also, the effect of energy intake on T2DM risk through the BMI was significant  
301 in men shifting to a “convenient” pattern, with an estimated increase in the energy intake  
302 increasing the T2DM risk through an increased BMI. In each one, the effect of energy intake  
303 on T2DM risk through the BMI had the same effect on T2DM risk that the changes in dietary  
304 intakes.



305 Regarding the changes in T2DM risk related to changes in dietary intakes, shifting from the  
306 “transitioning” pattern to the “prudent” or “traditional” pattern reduced the T2DM risks. This  
307 is in line with literature showing the protective effect of diets with high consumption of fruits,  
308 vegetables, legumes, whole grains, nuts, and fish, and low consumption of red and processed  
309 meats, refined grains, and sugar-sweetened beverages [31–33]. Our analyses however  
310 underline that a shift from the “transitioning” pattern to a “traditional” one did not reduce the  
311 T2DM risk as much as a shift toward a “prudent” pattern, especially among women. Yet,  
312 previous analyses had shown that the “traditional” pattern had higher overall dietary quality  
313 scores (evaluated using the Diet Quality Index-International (DQI-I) and the  
314 modified Programme National Nutrition Santé-Guideline Score (mPNNS-GS)) than the  
315 “prudent” one (65.4 vs. 64.0 points and 9.0 vs. 8.6 points, respectively) [13]. In addition, shifting  
316 from the “transitioning” pattern to the “convenient” pattern did not significantly change the  
317 T2DM risk whereas the diet quality score of the “convenient” pattern was much lower than the  
318 score of the “transitioning” one (54.6 vs. 60.8 points and 7.6 vs. 8.1 points, respectively). In the  
319 literature, dietary indexes reflecting the overall healthiness of the diet were associated with a  
320 reduction in T2DM incidence even if the quality of evidence was generally low [32, 34–36].  
321 For example, participants with high versus low Programme National Nutrition Santé-Guideline  
322 Score 2 (PNNS-GS2), Mediterranean dietary score, and DASH score had a reduction of 49%,  
323 15% and 20% in their T2DM risk, respectively [34, 36]. These results suggest a role of the  
324 quality of dietary patterns as a whole rather than specific components, supporting the idea that  
325 as foods interact with each other as part of the diet, it is important to capture the synergic effects  
326 caused by the dietary matrix [34]. Yet, in our study, it appears that overall dietary quality scores  
327 mask finer dietary characteristics that strongly impact T2DM risk. Indeed, this higher decrease  
328 in T2DM risk for shifting to “prudent” rather than toward the “traditional” one can be explained  
329 by the higher changes in intakes of whole grains, vegetables, processed meats (in women),

330 sugar-sweetened beverages, and tea. Also, specific food intake in “prudent” and “traditional”  
331 patterns increased the T2DM risk despite high overall diet quality scores for these patterns. In  
332 contrast, shifting from the “transitioning” to the “convenient” pattern did not significantly  
333 change the overall T2DM risk. Indeed, the changes in intakes of foods increasing the T2DM  
334 risk (i.e., fruits, sugar-sweetened beverages (in men), coffee, butter, and magnesium) was  
335 counterbalanced by changes in intakes in foods that allow decreased T2DM risk (i.e., whole  
336 grain products, green leafy, potatoes, red meat, processed meat, and tea). Note that more  
337 pronounced results in women may be due to the wider changes in the intakes.

338 Our results support the idea that the nutrition transition is advanced in the French West Indies  
339 [13] as the “transitioning” pattern group has a diet similar to the diet of the “convenient” pattern  
340 group except for higher intake of fruits and vegetables which has a small effect on the T2DM  
341 risk (relative risk in PRIME-Diabetes of 0.98 for fruits, 0.87 for green leafy vegetables, and  
342 0.98 for other vegetables), but have a significant weight on overall dietary quality scores. In the  
343 light of our results, our study emphasizes the limitation of overall diet quality scores to predict  
344 T2DM risk in concordance with previous reviews showing that diet quality scores are often  
345 modestly associated with mortality or disease risk, and do not predict morbidity or mortality  
346 significantly better than individual dietary factors [37]. This emphasises the need for specific  
347 recommendations in these populations, beyond global recommendations.

348 Among the foods involved in the T2DM risk identified in the literature, our study has identified  
349 key food groups based on the French West Indian diet, offering levers to prevent diabetes in  
350 these islands. Looking at the shift from the “transitioning” pattern to the “prudent” or  
351 “traditional” ones, the same foods are involved in the change in T2DM risk, but in different  
352 orders. Shift to the “prudent” pattern was stronger because the changes in food intakes are wider  
353 than the changes for the shift to the “traditional” pattern. Moreover, the Caribbean traditional

354 foods are not highly diabetes protective. For instance, fish is not a central element in reducing  
355 the T2DM risk, and traditional tubers are not even included in the model even if they have many  
356 potential beneficial effects on diabetes in mice [38–40]. However, as the change in dietary  
357 intake from the "transitioning" to the "traditional" diet is smaller than to the "prudent" one, it  
358 seems to be more feasible. And as it still leads to a high reduction in T2D risk, promotion of a  
359 "traditional" diet seems to be the best possible compromise. Especially as the "traditional" diet  
360 is more culturally acceptable, and as it is made up of local foods, it could be more economically  
361 accessible, therefore easier to promote and implement for the population.

362 The key food group associated with a reduction of the T2DM risk is whole grain products for  
363 which the increasing intake was associated with the larger effects. The protective effect of the  
364 whole grain product consumption against T2DM may be partly explained through reduced  
365 fasting glucose and insulin concentrations, reduced adiposity, lower concentrations of  
366 inflammatory markers (e.g. C reactive protein) and high content of several nutrients, vitamins,  
367 minerals, and phytochemicals for example [31, 36]. Similarly, the potential mechanistic  
368 explaining the protective effect of fruits and vegetables on the T2DM risk is mainly based on  
369 their fiber content, which has been shown to improve insulin sensitivity and secretion to  
370 overcome insulin resistance [31]. Another possible explanation is that vegetable and fruit intake  
371 indirectly influence T2DM risk by preventing weight gain and adiposity risk [31].

372 Our study underlines that reduction of processed meat intakes offers one of the most important  
373 strategies to reduce the T2DM risk. Indeed, processed meat intakes are positively associated  
374 with higher fasting glucose and insulin concentrations, and high amounts of sodium, haem iron,  
375 nitrates, nitrites for example [31, 36]. Another lever to reduce the T2DM risk in the French  
376 West Indies is to decline the consumption of sugar-sweetened beverages. Indeed, sugar-  
377 sweetened beverages have a high glycaemic index and their consumption is associated with

378 increased blood glucose concentration [31, 36]. Also, fructose in sugar-sweetened beverages  
379 promotes hepatic lipogenesis and insulin resistance and sugar-containing liquids negatively  
380 affect the regulation of hunger and satiety [31, 36].

381 Finally, our paper supports the recommendations that promoted the consumption of whole grain  
382 products, fruits, and green leafy vegetables to reduce the T2DM incidence and prevalence in  
383 the French West Indies. But in these islands, food is expensive, and a large part of the population  
384 is disadvantaged, so we need to combine action to increase these intakes. However, as  
385 previously underline in literature [31], reducing the consumption of risk-increasing foods seems  
386 to have more impact on T2DM risk than increasing risk-reducing foods. Yet, consumption of  
387 processed meat and sugar-sweetened beverages are markers of the nutritional transition that is  
388 still ongoing in the French West Indies, implying that these consumptions will increase thus  
389 leading to higher T2DM risk. Policies aiming at limiting these increases or even reducing these  
390 consumptions need to be implemented. However, as individuals reducing their consumption of  
391 risk-increasing foods are likely to replace it to some extent with something else, promoting risk-  
392 reducing foods is still important. Thus, promoting the “traditional” diet seems to be a good  
393 compromise, especially as it is culturally acceptable and economically accessible, and as a trend  
394 of purchasing local products occurs in the French West Indies [14]. In addition, beyond the  
395 positive impacts on the health of the population, it will also have a positive impact on the local  
396 food system as it favours the local economy as previously underline [15].

397 The interpretation of our results presents some limitations. First, a major limitation is that  
398 PRIME-Diabetes was parametrized with available relative risks from meta-analyses, mostly  
399 estimated for the general population independently of socioeconomic distribution in the  
400 population, while for some parameters, the actual risks may vary as a function of socio-  
401 demographic and health characteristics. The PRIME model does not allow to adjust a posteriori

402 for sociodemographic and economic characteristics that leads to estimate relative risks without  
403 accounting for important potential confounders. Additionally, in the absence of reliable  
404 information, we considered that the initial T2DM risk was the same for all the population  
405 subgroups examined in our study. In the French West Indian populations, mainly composed of  
406 African descendants and particularly marked by social inequalities, it is highly likely that the  
407 relative risks are different from those included in the original model. Also, in the Caribbean  
408 populations, women have statistically higher risks of T2DM than men [6, 41–43], unlike in  
409 mainland France and most northern countries. In addition, some nutritional factors were not  
410 included in the PRIME-Diabetes, either because they have not been sufficiently documented or  
411 due to a lack of detailed data on their contents in different foods [20]. Also, as most of the foods  
412 marker of the traditional diet was not included in the PRIME-Diabetes, the model is not  
413 admirably adapted to the Caribbean diet where potatoes are not widely consumed, unlike  
414 traditional tubers. In the present analyses, alcohol intake, and physical activity level were not  
415 included in the models although they are important risk factors. We decided not to consider  
416 alcohol consumption as it's highly misreported in our sample and as we know from descriptive  
417 analysis that the “transitioning” pattern has the highest alcohol consumption. Thus, we can  
418 imagine that considering alcohol consumption in our model will have biases the results by  
419 showing unrealistic decreases in diabetes risks due to large decreases in alcohol consumption.  
420 Also, given that a large part of the population of the French West Indies belonged to low  
421 socioeconomic classes, the household participation rate from the Kannari survey was around  
422 50% which may lead to a selection bias. However, the use of weights should have attenuated  
423 this limit. Finally, the dietary patterns used in our analysis are based on the latest data available  
424 for the French West Indies (Kannari survey from 2013). They may not therefore reflect current  
425 intakes.

**426 Conclusion**

427 Despite the role of ageing and other non-modifiable risk factors in morbidity and mortality from  
428 diabetes, changes in diet have a strong impact on the T2DM risk. Shifting to a "prudent" diet  
429 will widely reduce the T2DM risk in the French West Indian populations, as a shift to a  
430 "traditional" diet to a lesser extent, due to increased consumption of fruits, green leafy  
431 vegetables, and mostly whole grain products, and most importantly the reduced consumption  
432 of processed meat and sugar-sweetened beverages. Therefore, to stop the increase in T2DM  
433 prevalence and reduce this burden in these populations, one lever could be to help adults to  
434 change their diet toward a "prudent" or a "traditional" diet by promoting them.

## **Declarations**

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**Conflict of interest:** The authors declare that they have no conflict of interest.

**Availability of data and material:** Data described in the manuscript, codebook, and analytic code cannot be made available because they were provided by the French public health agency (Santé Publique France) and are not accessible to the public. Requests can be made to the French public health agency.

**Authors' contributions:** The authors' responsibilities were as follows: CM and LGS designed the study, ZC drafted the manuscript, ZC performed the statistical analysis, PL performed the PRIME-Diabetes model, PL, CM and LGS contributed to the data interpretation and revised each draft for important intellectual content. All authors read and approved the final manuscript.

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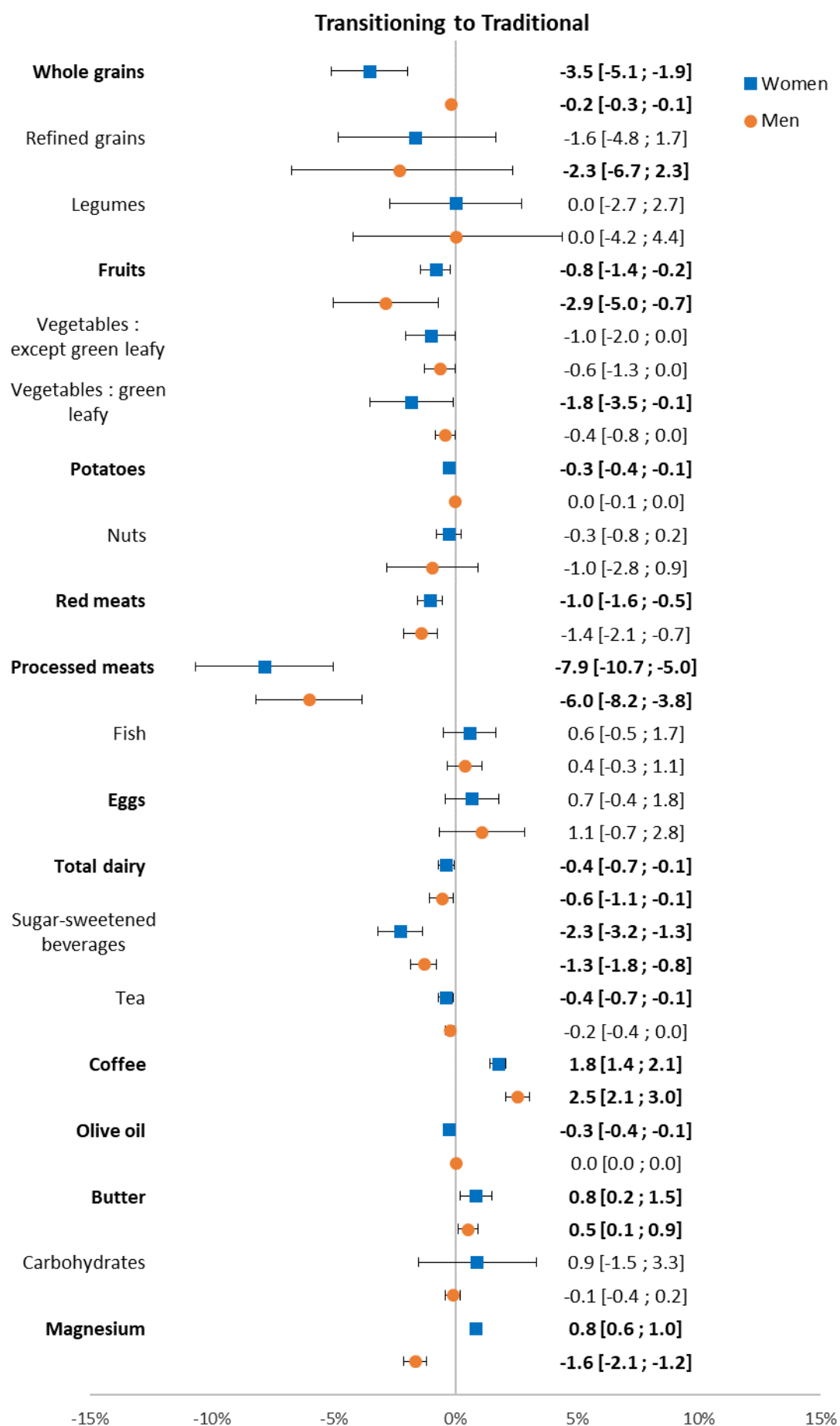


**Table 1.** Modelled changes on the risk of Type-2 Diabetes (percentage) if Guadeloupean and Martinican adults ( $\geq 25$  years) from the “transitioning” pattern shifted to another pattern (“traditional”, “prudent” or “convenient), Kannari study ( $n = 1,063$ ).

	Transitioning to Traditional		Transitioning to Prudent		Transitioning to Convenient	
	Women	Men	Women	Men	Women	Men
Effect of energy intake through the BMI	<b>-14.1</b> [-23.3 ; -3.0]	<b>-0.8</b> [-1.1 ; -0.5]	-13.2 [-24.3 ; 0.7]	-6.1 [-13.6 ; 2.4]	-15.1 [-49.0 ; 43.3]	<b>3.4</b> [2.5 ; 4.3]
Dietary effect	<b>-16.0</b> [-22.0 ; -9.6]	<b>-14.2</b> [-20.7 ; -7.0]	<b>-23.0</b> [-28.7 ; -16.9]	<b>-19.0</b> [-23.3 ; -14.4]	-1.5 [-10.6 ; 8.3]	2.5 [-4.1 ; 9.4]

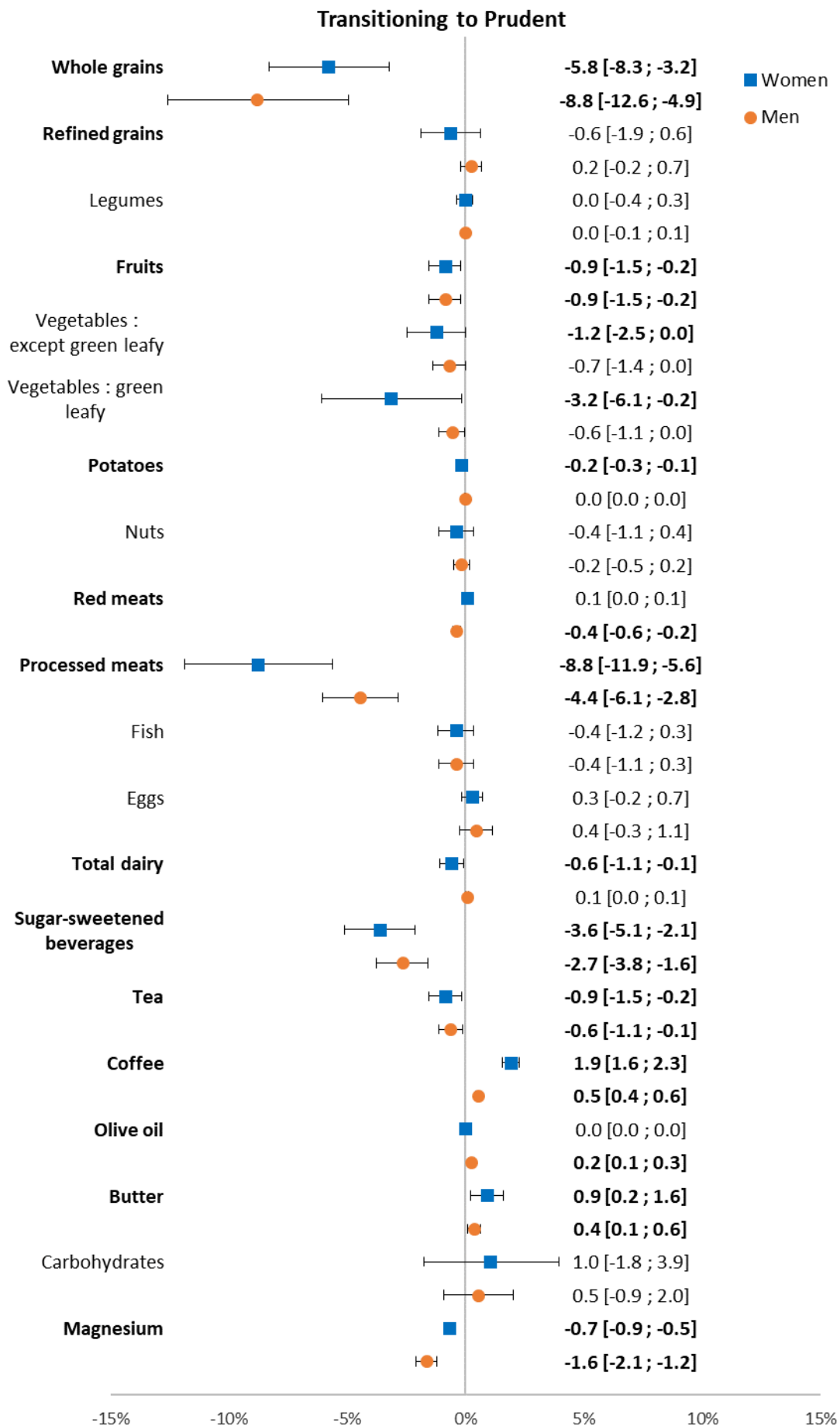
Abbreviation: BMI: Body Mass Index

Values are presented as percentage (%) and [95% uncertain interval].



**Figure 1.** Modelled impact of dietary changes on the risk of Type-2 Diabetes (percentage) if Guadeloupean and Martinican adults ( $\geq 25$  years) from the “transitioning” pattern shifted to the “traditional” pattern, Kannari study ( $n = 1,063$ ).

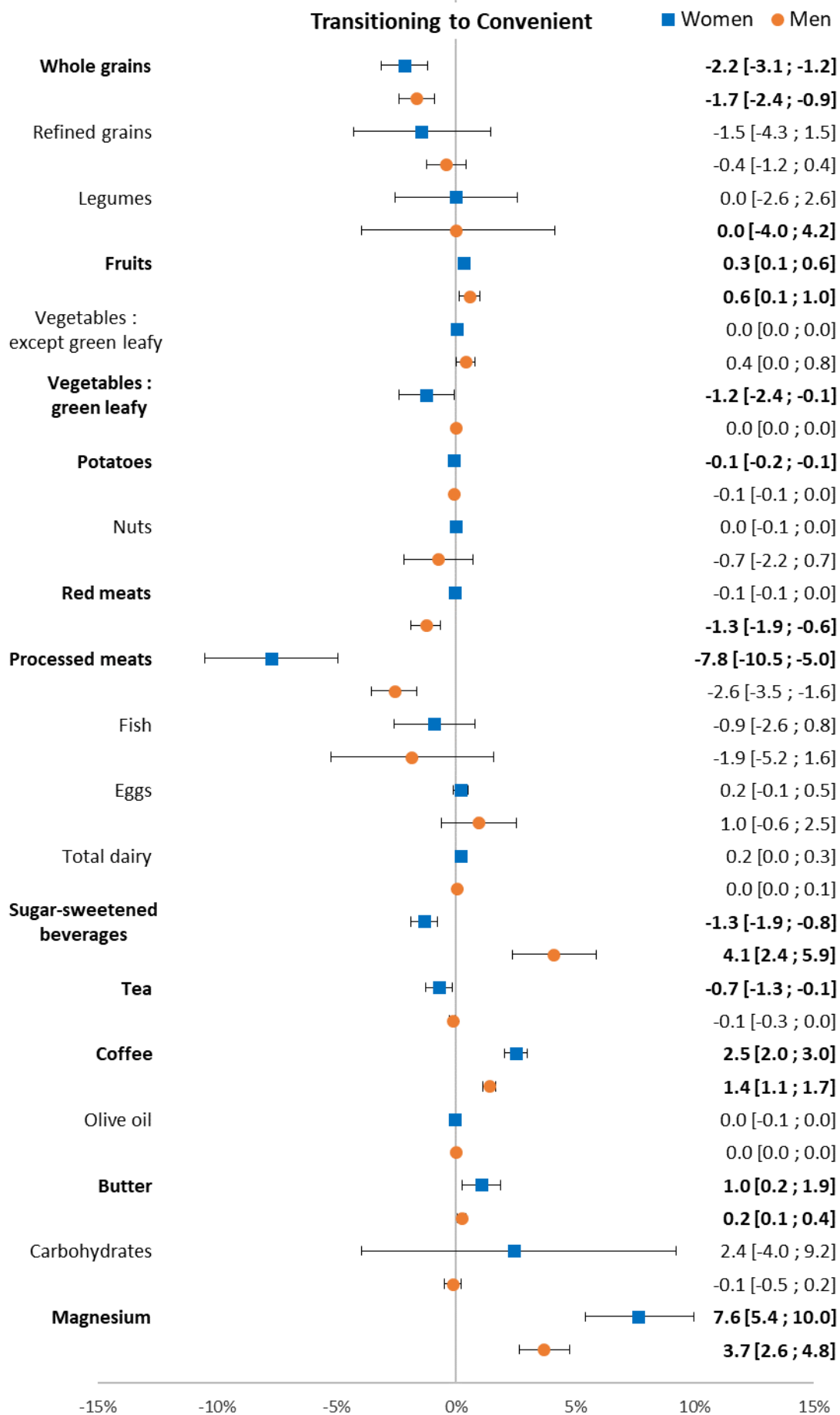
Values are presented as percentage (%) and [95% uncertain interval].



**Figure 2.** Modelled impact of dietary changes on the risk of Type-2 Diabetes (percentage) if Guadeloupean and Martinican adults ( $\geq 25$  years) from the “transitioning” pattern shifted to the “prudent” pattern, Kannari study ( $n = 1,063$ ).

Values are presented as percentage (%) and [95% uncertain interval].





**Figure 3.** Modelled impact of dietary changes on the risk of Type-2 Diabetes (percentage) if Guadeloupean and Martinican adults ( $\geq 25$  years) from the “transitioning” pattern shifted to the “convenient” pattern, Kannari study ( $n = 1,063$ ).

Values are presented as percentage (%) and [95% uncertain interval].