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Influences of Public Health Policies on Individuals' Dietary Behaviours: A Large Cohort Study from Chile

Pamela Serón[1,2,a,b,], María J. Oliveros[1,2,a,c], Mahshid Deghan[3,b], Roxanna Solano[3,d], Sergio Muñoz[2,4,b], Fernando Lanas[2,5,b], Shrikant I. Bangdiwala[3,6,b].*

[1]Departamento de Ciencias de la Rehabilitación, Universidad de La Frontera. Temuco, Chile.
[2]Centro de Excelencia CIGES, Universidad de La Frontera. Temuco, Chile.
[3]Population Health Research Institute, McMaster University. Hamilton. ON, Canada.
[4]Departamento de Salud Pública, Universidad de La Frontera. Temuco, Chile.
[5]Departamento de Medicina Interna, Universidad de La Frontera. Temuco, Chile.
[6]Department of Health Research Methods, Evidence, and Impact, McMaster University. Hamilton, ON, Canada.
[a]Kinesióloga.
[b]PhD.
[c]MSc.
[d]Research Manager.

Influencia de las políticas de salud pública en el comportamiento alimentario de las personas: Un estudio de cohorte en Chile

ABSTRACT

The Chilean law of food labeling and advertising was promulgated in 2012 and was implemented in consecutive phases until 2019. ***Aim:*** *To determine the change in dietary behaviour experienced by the participants of a large Chilean cohort and to identify predictors of change.* ***Methods:*** *The sample included 2.608 adults between 35 and 70 years old recruited between 2006 and 2009 and followed on average over 10.8 years. Food intake was measured using a validated Food Frequency Questionnaire twice, at baseline, between June 2006 and October 2009, and after ten years of follow-up, between March 2018 and October 2019. The modified Alternative Healthy Eating Index (mAHEI) assessed participants' diet quality. Also, other socio-demographic and health variables were measured.* ***Results:*** *During follow-up, the composition of the diet changed with an increase in the consumption of carbohydrates and fats and a decrease in the consumption of proteins. Also, 31.6% of participants improved their diet quality, but it worsened among 32.6% of participants. Being female, having a major health event, having a high educational level, and having sufficient household income were predictors for positive diet quality changes.* ***Conclusions:*** *During ten years of follow-up, the majority of participants did not improve their eating habits. Predictors of positive change were essentially the socio-demographic background and the occurrence of health events. Our findings suggest that it is necessary to reinforce policies related to diet with even more profound interventions than those already implemented.*

Keywords: *Diet, Healthy; Feeding Behavior; Public Policy.*

**Corresponding Author: Pamela Serón / pamela.seron@ufrontera.cl*
Claro Solar #115. Of 304. Temuco, Chile.

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RESUMEN

La ley chilena de etiquetado y publicidad de alimentos fue promulgada en 2012 y se implementó en fases consecutivas hasta 2019. ***Objetivo:*** *Determinar el cambio en la conducta alimentaria experimentado por los participantes de una gran cohorte chilena e identificar predictores del cambio.* ***Métodos:*** *La muestra incluyó 2.608 adultos entre 35 y 70 años reclutados entre 2006 y 2009 y seguidos en promedio durante 10,8 años. La dieta se midió utilizando un Cuestionario de Frecuencia de Alimentos validado, al momento de reclutamiento del participante en la cohorte, entre junio de 2006 y octubre de 2009, y después de diez años de seguimiento, entre marzo de 2018 y octubre de 2019. Se calculó el Índice Alternativo de Alimentación Saludable modificado (mAHEI) para determinar la calidad de la dieta de los participantes. Además, se midieron otras variables sociodemográficas y de salud.* ***Resultados:*** *Durante el seguimiento, la composición de la dieta cambió con un aumento en el consumo de carbohidratos y grasas y una disminución en el consumo de proteínas. Además, el 31,6% de los participantes mejoró la calidad de su dieta, pero empeoró entre el 32,6% de los participantes. Ser mujer, haber tenido un evento de salud importante, tener un nivel educativo alto y disponer de ingresos familiares suficientes fueron factores predictores de cambios positivos en la calidad de la dieta.* ***Conclusiones:*** *Durante los diez años de seguimiento, la mayoría de los participantes no mejoraron sus hábitos alimentarios. Los predictores de cambios positivos fueron esencialmente los antecedentes sociodemográficos y la aparición de eventos de salud. Nuestros hallazgos sugieren que es necesario reforzar las políticas relacionadas con la dieta con intervenciones aún más exhaustivas que las ya aplicadas.*

Palabras clave: *Conducta Alimentaria; Dieta Saludable; Política Pública.*

Overall health, as expressed in Disability-Adjusted Life-Years (DALY), has improved over the past ten years globally. However, this trend varies by age group, with less change among 50 and older adults. Previous studies have shown that ischemic heart disease and stroke are the top-ranked causes of DALYs among 50-year-old and older adults in 2019[1]. Lifestyle behaviors such as smoking, a sedentary lifestyle, and poor diet quality are known as potential risk factors for cardiovascular disease (CVD)[2]. Therefore, focusing on these modifiable risk factors is imperative as primary chronic disease prevention[3].

In Chile, non-communicable diseases (NCDs) are estimated to account for 85% of all deaths. While the risk of premature death due to NCD has declined over time, the prevalence of obesity has doubled[4], making high body mass index one of the most important causes of premature death and disability[5]. In response to this complex scenario, various public health actions and other policies have been implemented over time to improve lifestyle behaviours, such as dietary habits. One of the most important and broadly encompassing policies is the Chilean law of food labeling and advertising, which attempts to provide structural

responses to obesity and NCD prevalence[6]. In 2012, Law 20,606[7] was promulgated, and despite industry setbacks and other challenges, the implementation started with consecutive phases from 2016 to 2019[8]. In this context, we were interested in exploring whether people have changed their eating habits since the implementation of this law and identifying the most important factors for adherence to the change.

The Chilean arm of the Prospective Urban and Rural Epidemiology (PURE) cohort is an ongoing is an ongoing study that started in 2006. The multinational PURE study is investigating how modifiable risk factors develop and influence cardiovascular disease, diabetes, lung diseases, cancers, kidney disease, brain health, and injuries in over 225,000 participants from more than 1,000 urban and rural communities in 27 high, middle and low-income countries. The PURE study provides a unique opportunity to investigate whether dietary changes have occurred over time. Therefore, in this study, we aimed to document the magnitude of the changes in dietary habits of the Chileans participating in the PURE study over ten years and identify positive change predictors.

Methods

The Chilean arm of the multinational PURE study recruited all participants in the Araucanía region of Chile. The protocol and findings of the PURE study have been published previously[9,10,11]. Dietary data, sociodemographic characteristics, other lifestyle behaviors, and clinical information were collected during baseline (between 2006 and 2009) and follow-up visits (the latest 2018-2019). This study was conducted according to the Declaration of Helsinki and all procedures involving research study participants were approved by the Comité Ético Científico del Servicio de Salud Araucanía Sur, Chile. Written informed consent was obtained from all subjects.

The Chilean arm of the PURE study recruited 3,594 participants at baseline. The sampling in the urban area of Temuco was random and multi-stage. A starting point was selected to identify households, and from each household, all adults between 35 and 70 years of age who consented to participate in the study were enrolled. Due to feasibility, non-probability sampling was conducted in rural areas, and adults from 14 villages with less than 2000 inhabitants and more than 50 km from a larger city were invited to participate in the study. At the baseline visit and in subsequent follow-up visits, a series of questionnaires were administered and physical measurements were taken.

Participants' habitual dietary intake was measured using a Food Frequency Questionnaire (FFQ), which was validated among Chilean participants[12]. The FFQ was administered at baseline and the last follow-up visit. The FFQ contains 109 food items, each with options about the frequency of consumption during the previous year. The food list includes dairy products, fruits, vegetables, meat, eggs, fish, bread, cereals, other starches, beverages, sweets, mixed dishes, intake of mineral and vitamin supplements, and oils. The daily consumption of 43 macro and micro-nutrients and total energy consumption were estimated using the nutrient database. The nutrient database was primarily based on the United States Department of Agriculture food composition database (releases 18 and 21), modified regarding the Chilean food composition table, and supplemented with recipes of local mixed dishes. Also, for each participant, we modified the Alternate Healthy Eating Index (AHEI)[13,14] to measure participants' overall diet quality. To compute the modified AHEI (mAHEI) score, eight components of the diet were considered: daily intakes of vegetables, fruits, legumes and nuts, red meat and processed meat, sugar-sweetened beverages, omega 3, polyunsaturated fatty acids, and trans fat. Each component contributed 0-10 points to the total score; a score of 10 indicates a healthy diet, whereas a score of 0 represents the least healthy diet quality. Intermediate intakes were scored proportionately between 0 and 10. All component scores were summed up to obtain a total mAHEI score ranging from 0 for the poorest diet to 80 for the healthiest diet.

The socio-demographic variables age, sex, rural or urban location, level of education, smoking, alcohol intake, and income were obtained by standard questionnaire. Education was classified as

none, primary, secondary, technical, and university. The purchasing power parity (PPP) adjusted household income was calculated. Weight was measured using the BC-554 IRONMAN® Body Composition Monitor digital scale with as little clothing as possible. Height was measured to the nearest 0.1 cm by a measuring tap, with the participant standing symmetrically and barefoot against the wall on a flat surface. Body mass index was calculated by weight divided by height squared. Waist circumference was measured with an anthropometric tape (not extensible), with the participant standing, the abdomen relaxed, arms at the sides, and feet together, and the weight equally distributed on both legs. The measurement was made in the horizontal plane, one centimeter above the navel. According to the PURE Study protocol, all anthropometric measurements were made by trained personnel in a standardized manner. Each measurement was performed twice, and the average of both measurements was reported.

Physical activity was measured by the long version of the International Physical Activity Questionnaire (IPAQ), which has been translated, adapted, and shown to be valid and reliable for use in several countries[15]. This instrument has also been used in other research in Chile[16,17]. This multidimensional questionnaire collects information on energy expenditure as light, moderate, and vigorous activities related to work, household, transport, and leisure. For this study, compliance with the World Health Organization (WHO) global recommendation for adult physical activity was determined. This corresponds to 150 minutes per week of moderate aerobic physical activity, or some form of aerobic vigorous physical activity for 75 minutes, or an equivalent combination of moderate and vigorous activities, and the activity should be performed in sessions of at least 10 minutes. Also, information on sitting time was collected, and those in the highest quartile of sitting minutes were defined as sedentary.

The history of clinical events was obtained during follow-up, and events were adjudicated and confirmed through the review of clinical records by a panel of clinicians and researchers. The relevant clinical events were acute myocardial infarction, stroke, heart failure, cancer, and diabetes. Additionally, five questions were asked about whether advertising had impacted their choice of buying some foods (eg. oil, flour, rice, soft drinks, and snacks), creating a score from 1 to 5, where a score of 4 or 5 indicated their were likely to be impacted by publicity.

Statistical Analysis

To measure the change in eating habits, we compared individuals' dietary intake at baseline and follow-up using the daily intake of some nutrients, food items, and overall diet quality measured by mAHEI. Further, participants were grouped into tertiles based on their mAHEI score at baseline, which established the cut-off points. These cut-offs were then used to assess whether participants' diet quality improved, worsened, or remained stable over time. We defined an improvement as moving up one or two categories by the last follow-up, and a worsening as dropping one or two categories. Differences between groups (tertiles and categories of changes) were tested using one-way analysis of variance (ANOVA) for continuous variables and using Scheffé's adjustment for multiple comparisons for categorical variables.

Predictive variables evaluated were sex, age, location, education, PPP household income, physical activity, sedentarism, smoking, drinking alcohol, body mass index, waist circumference, clinical events, and publicity perception. Predictive logistic regression models were performed with a stepwise-backward selection method. The significance level for eliminating a variable from the model was set at 0.2, while the significance level for keeping a variable in the model was set at 0.15. The model was validated by split-sample validation, which calculated the sensitivity, specificity, and positive and negative predictive values for the model. Additionally, the receiver operating characteristic (ROC) curve was plotted, and the area under the curve (AUC) was calculated. After validation of the final model on the total sample, the adjusted probabilities and predictions were ranked.

Results

Up to September 2019, of the 3,594 participants, 2,934 individuals had completed follow-up visits, with a mean follow-up of 10.8 years, and information on dietary habits was available for 2,608 participants (88.9% of participants with complete follow-up). Table 1 shows the baseline sociodemographic and health characteristics of all participants by tertiles of mAHEI. The mean age at recruitment

Table 1. Baseline characteristics of participants in PURE-Chile cohort, total and according to mAHEI tertiles (n= 2608).

Characteristics	Baseline (2006 To 2009)			
	Total	Tertil 1	Tertil 2	Tertil 3
Age (y), mean, SD	51.39 ±9.5	49.02±8.83*	51.52±9.56**	53.75±9.50***
Female, %	67.98	58.48*	70.09**	75.55***
Urban population, %	81.73	78.87	81.54**	85.14***
Secondary and tertiary education, %	63.39	65.54	61.93	62.87
BMI (kg/m^2), mean, SD	29.74±4.96	29.43±4.82	30.04 ± 4.94	29.75 ± 5.10
Waist circumference (cms), mean, SD	94.56±11.54	94.59 ± 11.13	94.96 ± 11.68	94.1 ± 11.79
Never smoker, %	55.09	52*	59.69**	53.47
Physical activity (MET min/week), mean SD	3687.38±4268.09	3382.13 ± 4212.08	3495.27 ± 3901.65**	4226.22 ±4654.20***
WHO recommendation of Physical Activity, %	80.55	78.20*	82.39	81.14***
mAHEI (score 0 to 80), mean, SD	53.40±8.24	44.54±4.55*	53.5±1.96**	62.60±4.66***
Fruits (servings/day), mean, SD	2.65±1.66	2.02 ± 1.40*	2.55 ± 1.65**	3.41 ± 1.61***
Vegetables (servings/day), mean, SD	3.77±2.13	3.17 ± 2*	3.62 ± 1.87**	4.54 ± 2.27***
Total energy (kcal), mean, SD	1734.29±551.09	1695.38 ± 535.77	1674.99 ± 561.27**	1839.2 ± 534.67***

Abbreviations: BMI= Body mass index; MET= Metabolic equivalent of task; WHO= World Health Organization; mAHEI= Modified alternate healthy eating index. *tertile 1 different to 2 ($p<0.05$); **tertile 2 different to 3 ($p<0.05$); ***tertile 3 different to 1 ($p<0.05$).

was 51.4±9.50 years; 68% of the participants were females, and 82% were from urban areas. Approximately 63% of participants had a secondary or tertiary education level. Most of the follow-up FFQ collected occurred after the second stage of implementation of the Chilean law. Specifically, 10.9% of FFQ were collected before 25 June 2018, i.e., during the first stage of implementation of the law, 73.4% were collected between 26 June 2018 and 25 June 2019, i.e., when the first and second stages of the law had already been implemented, and 15.7% were collected after 26 June 2019, when the law had already been fully implemented.

Table 2 demonstrates the mean change

Table 2. Mean mAHEI and specific nutrients at baseline and change after 10 years of follow-up for the PURE-Chile cohort (n=2608).

NUTRIENT / FOODS	Baseline (Mean ± SD)	Change (Mean ± SD)
mAHEI score	53.40 ± 8.24	-4.08 ± 9.49
Protein (grams)	69.18 ± 24.18	-41.49 ± 26.75
Percent of energy from protein	16.07 ± 2.30	-0.35 ± 3.34
Carbohydrates (grams)	258.06 ± 82.82	-146.55 ± 96.28
Percent of energy from carbohydrate	59.76 ± 5.91	1.54 ± 10.08
Fat/Lipids (grams)	51.06 ± 21.66	-30.12 ± 23.85
Percent of energy from total fat	26.15 ± 5.95	0.17 ± 9.51
Total Saturated Fatty Acids	14.32 ± 6.64	-7.10 ± 7.83
Percent energy intake from saturated Fat	7.33 ± 1.92	1.87 ± 4.52
Total Monounsaturated Fatty Acids	20.07 ± 9.50	-12.43 ± 10.31
Percent energy intake from monounsaturated fat	10.29 ± 3.04	-0.68 ± 4.61
Total Polyunsaturated Fatty Acids	11.43 ± 5.11	-7.54 ± 5.54
Percent energy intake from polyunsaturated fat	5.89 ± 1.72	-1.08 ± 2.23
Dairy (grams/day)	179.95 ± 204 01	-82.22 ± 217.07
Total Sugar (grams)	67.52 ± 33.20	-35.76 ± 37.54
Unprocessed red meat (grams/day)	24.74 ± 22.72	-18.01 ± 23.82
White meat (grams/day)	31.56 ± 25.52	-21.76 ± 27.80
Refined grains (grams/day)	207.07 ± 92.92	-141.45 ± 98.72
Total Fibre in gram	31.06 ± 11.88	-15.66 ± 13.78
Fruits in servings/day	2.65 ± 1.66	-1.03 ± 2.07
Vegetables in servings/day	3.77 ± 2.13	-2.17 ±2.27
Energy in kcal	1734.29 ± 551.09	-1010.90 ± 623.55

of nutrients, some food items, and the mAHEI score between the baseline and the last follow-up. We found that the quality of diet, as measured by mAHEI, decreased in general, and there was a decrease in the consumption of almost all nutrients, including sugar and saturated fatty acids. Diet composition changed as consumption of carbohydrates and fats increased and protein intake decreased (Figure 1).

When we assessed change in diet quality as a categorical variable, we found that 31.6% of the participants improved their diet while the quality of their diet worsened in 32.6% of participants. Table 3 presents the characteristics of participants by category of change in mAHEI tertiles.

The predictors of a positive change in diet were sex, education, occurrence of health events, and PPP household income. The sensitivity and specificity of the model were 46% and 61%, respectively, while the positive predictive value was 53% and the negative predictive value was 54%. The area under the ROC curve was 0.5452 (Figure 2). Those with the highest change in their diet quality were more likely to be female with at least a secondary level of education, those who suffered major health events or had a sufficient household income (58.2%; 95% CI 51.0% - 65.4%). By contrast, men with a primary level of education, no major health events, or insufficient household income were less likely to change their diet (38.8% 95%CI 32% - 45.7%). All the adjusted probabilities and predictions are presented in Table 4.

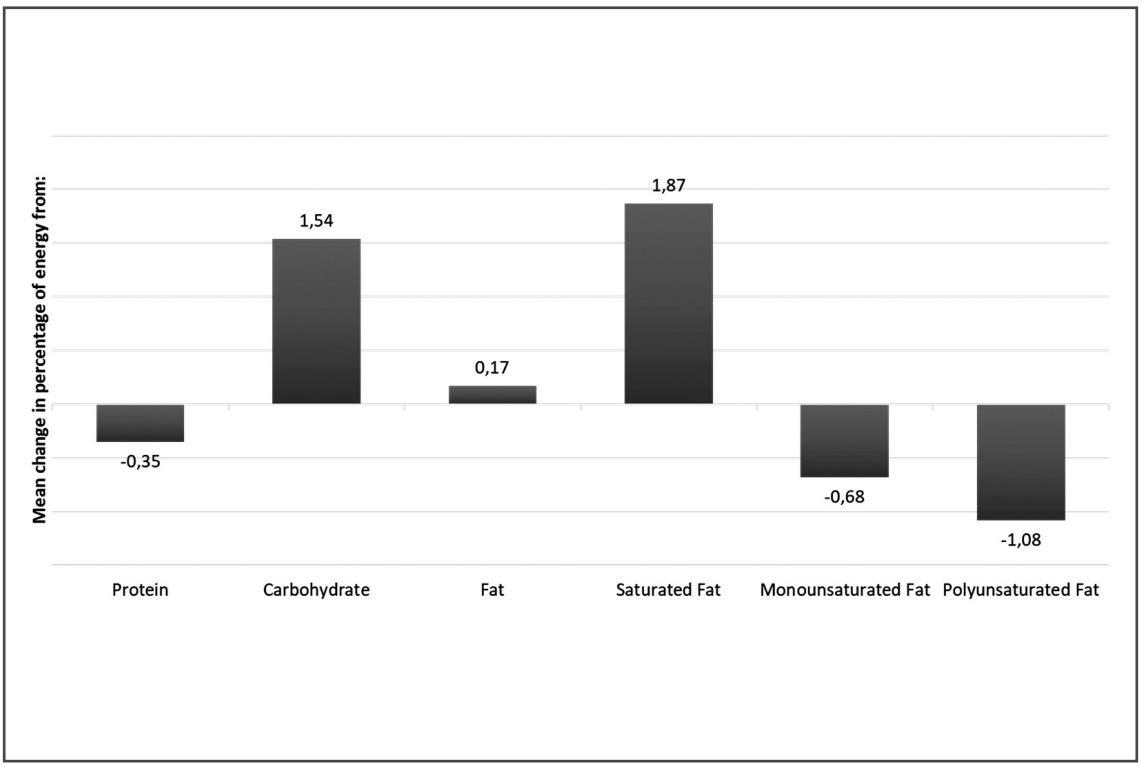

Figure 1: *Mean change in diet components expressed as the percentage of energy provided by each one.*

Table 3. Characteristics of participants by category of change in mAHEI tertiles.

	Diet quality worsened (n= 850)	Diet quality maintained (n= 933)	Diet quality improved (n= 825)
Proportion of participants in each change category, %	32.59	35.77	31.63
Change in mAHEI baseline to follow-up, Mean (SD)	-11.57±6.43*	-0.39±5.71**	8.82±5.23***
Baseline mAHEI, mean (SD)	58.76±5.88*	49.64±7.64**	46.84±5.26***
Follow-up mAHEI, mean (SD)	47.19±4.78*	49.25±6.76**	55.66±4.76***
Female, %	70.86*	65.10	66.50***
Age, mean (SD)	52.79±9.77*	50.02±9.27	50.67±8.61***
Secondary or teciary Education, %	79.80	79.68	81.89
Urban population (%)	82.81	81.83	78.57
Physically active according WHO, %	80.57	80.21	81.82
BMI, mean (SD)	29.78±4.99	29.66±4.9	29.82±5.04
Waist circumference (cms)	94.68±11.84	94.41±11.31	94.62±11.24
Never Smoker, %	55.34	54.18	57.11
Total energy (kcal), mean (SD)	1786.04±556.48*	1694.48±548.48	1678.78±517.39***
History of clinical events, %	14.95	13.50	12.32

Abbreviations: mAHEI= Modified alternate healthy eating index; BMI= Body mass index. *Different from "Diet quality maintained" ($p<0.05$); **Different from "Diet quality improved" ($p<0.05$); ***Different from "Diet quality worsened" ($p<0.05$).

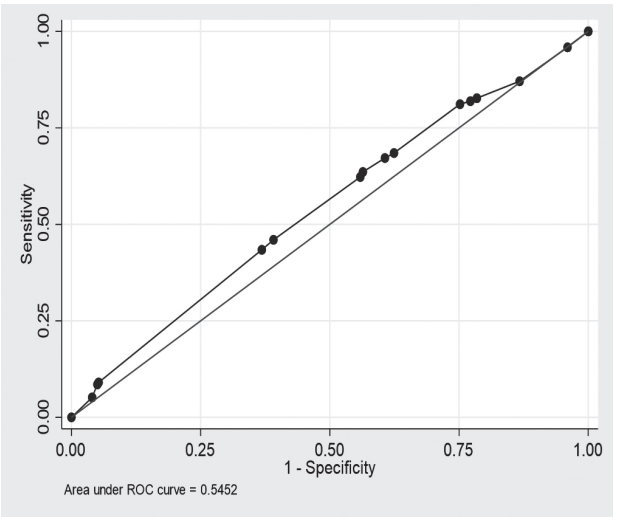

Figure 2: *Area under ROC curve of the predictive model.*

Table 4. Ranking of adjusted probabilities and predictions for positive change in eating behaviour.

Ranking	Predictive profile				Probability	95% Confidence Interval
	Sex	Secondary education at least	Major health event	Household budget		
1	Female	Yes	Yes	Sufficient	58.21%	51.04% - 65.38%
2	Female	Yes	Yes	Insufficient	54.06%	44.61% - 63.51%
3	Male	Yes	Yes	Sufficient	53.37%	45.40% - 61.33%
4	Female	No	Yes	Sufficient	53.06%	45.24% - 60.89%
5	Female	Yes	No	Sufficient	52.99%	49.28% - 56.71%
6	Male	Yes	Yes	Insufficient	49.16%	39.04% - 59.28%
7	Female	No	Yes	Insufficient	48.85%	40.38% - 57.32%
8	Female	Yes	No	Insufficient	48.79%	41.52% - 56.05%
9	Male	No	Yes	Sufficient	48.15%	39.70% - 56.61%
10	Male	Yes	No	Sufficient	48.09%	43.22% - 52.96%
11	Female	No	No	Sufficient	47.78%	42.59% - 52.97%
12	Male	No	Yes	Insufficient	43.97%	34.94% - 52.99%
13	Male	Yes	No	Insufficient	43.90%	35.97% - 51.84%
14	Female	No	No	Insufficient	43.60%	37.38% - 49.82%
15	Male	No	No	Sufficient	42.92%	36.95% - 48.88%
16	Male	No	No	Insufficient	38.85%	31.98% - 45.71%

Discussion

In this large cohort study, we found that participants mainly maintained or worsened their diet quality during ten years of follow-up. One-third of participants who improved their diet quality were women who suffered a major health event, had a higher level of education, or had a sufficient household income. In general, the consumption of different nutrients and food groups decreased over time. However, the composition of the diet changed with lower protein intake and higher intake of fat (especially saturated) and carbohydrates at follow-up compared with baseline.

It may be noteworthy that our predictive model did not detect the influence of some variables, such as the perception of food advertising or other concomitant risk factors, such as physical activity or smoking, and we did not find any improvement in overall diet quality despite the expectation that implementing public policies would impact individuals' eating habits. This might partly be explained by The Chilean law of food labeling and advertising mainly targeted children[8] while our study population was adults and older adults. A qualitative study conducted in Chile one year after the implementation of the front-of-package label reported that the degree of use of warning labels varied among mothers, but their children, particularly the youngest, had positive attitudes toward the regulation[18]. Secondly, it is known that older adults usually decrease their food intake due to aging[19,20]. So, we must consider that about 60% of participants were older adults after ten years of follow-up. Further, behavioral changes are not a rapid or permanent process. According to the Transtheoretical or Stages of Change Model, another study conducted in Chile[21] reported that most adults were in the pre-contemplation stage for most foods, the first stage out of five. Considering the incomplete implementation of the law at our last follow-up visit might indicate that our study participants were in a pre-contemplation stage.

Our results are similar to those of other longitudinal studies that evaluated diet change. A study conducted in the United States[22] investigated behavioural changes among 2,652 participants with ischemic heart disease and showed that dietary quality improved with age. It was suggested that this might have been due to the attention that study participants received or due to reverse causation. Further, similar to our findings, this study reported a positive change in diet among women with a higher level of education.

A cohort study from Australia[23] followed 2,111 adults older than 55 years for four years and reported that the dietary patterns were unchanged over time. Also, a higher level of education and favorable baseline lifestyle characteristics were predictors of positive changes in dietary patterns. Similar results were reported from a cohort of 8,161 women from Australia with 12 years of follow-up[24]. In this study, women who did not improve their diet quality were more likely to be overweight or obese and were smokers. The findings of these two studies[23,24] are partly different from our findings, specifically about other lifestyles as predictors, where we found no predictive association. This may be due to the shorter follow-up time in the first study and the sex-specific nature of the second study.

Our study has strengths, including the large sample size and high follow-up rate (over 85%). Also, we used an FFQ specifically developed and validated for our study population. In this large-scale study, we identified important factors for improving interventions at the primary and secondary prevention levels, as well as public policy. However, there are some potential limitations. Considering losses to follow-up and the fact that some participants did not respond to the FFQ, there was an attrition of 27%. While most lifestyle characteristics are not different, there is a tendency for the PURE study participants included in this analysis to be more female, more urban, and more educated than those not included, which could have introduced a non-response bias that potentially magnified the detected positive change in dietary habits. Another limitation could be the fact that there were no intermediate measurements that allowed observing a secular trend. In addition, the predictive capacity of our model is poor, perhaps because we only included the covariates available in our cohort, such as demographic and socioeconomic status. However, the potential

determinants come from broader spheres at the individual (biological, demographic, psychological, and situational aspects), interpersonal (social and cultural aspects), environmental (such as the obesogenic environment), and political levels[25]. Further, we must also be aware of the complexity and challenges inherent in nutritional studies.

In conclusion, we found that most participants did not change their eating habits. Some predictors of positive change were sex, education, the occurrence of health events, and household income. Our results suggest that diet-related policies must be reinforced with even more profound interventions than those already implemented, encompassing environmental spheres and addressing socioeconomic inequalities.

Acknowledgments

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Ethical approval

This study was conducted according to the Declaration of Helsinki and all procedures involving research study participants were approved by the Comité Ético Científico del Servicio de Salud Araucanía Sur, Chile. Written informed consent was obtained from all participants.

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