Catalogue no. 82-003-X
ISSN 1209-1367

Health Reports

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Release date: November 18, 2020

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DOI: https://www.doi.org/10.25318/82-003-x202001100001-eng

ABSTRACT

Background

A larger share of ultra-processed foods and drinks (UPF) in the diet is increasingly linked with poor diet quality, weight gain and elevated risk of diet-related chronic disease. This study used 2015 national-level data, the most recent available, to characterize the intake of UPF among Canadians and to examine changes since 2004.

Methods

The 2004 and 2015 Canadian Community Health Surveys provided 24-hour dietary recall data for Canadians aged 2 or older. All food and drink items were classified according to type of food processing using the NOVA classification. The mean energy contribution of UPF (as a percentage of total daily energy intake) was compared across survey years for the overall population and for eight age-sex groups. The National Cancer Institute's methodology was used to assess the distribution of usual energy contributed by UPF.

Results

On average, UPF contributed 47.8% (95% CI: 47.3% to 48.3%) of total daily energy in 2004 and 45.7% (95% CI: 45.0% to 46.4%) in 2015 among the overall population, and more than half of total daily energy among children and adolescents. Both the mean energy contribution of UPF and their usual energy distribution shifted downward since 2004 for all age-sex groups, except among adults aged 55 or older. The energy contributions of soft drinks, fruit juices and fruit drinks declined, particularly among children and adolescents. Ultra-processed breads contributed more energy in 2015 for nearly all age-sex groups.

Conclusions

As in 2004, the overall dietary share of UPF in Canada remained high in 2015, but intakes of some UPF, particularly beverages, declined. The energy contribution of UPF remained highest among children and adolescents, and increased among adults aged 55 or older.

Keywords

Canadian Community Health Survey, nutrition surveys, dietary intake, ultra-processed food, NOVA

AUTHORS

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What is already known on this subject?

- The food supply in Canada and many other countries is now dominated by ultra-processed food and drink products (UPF). UPF are characterized by low nutritional quality and the presence of additives.
- A greater share of UPF in the diet is increasingly linked with poor diet quality, weight gain and elevated risk of developing a number of chronic conditions.
- The NOVA classification is a relatively new system to classify foods and drinks according to type of food processing. Foods and drinks are classified as unprocessed or minimally processed, processed culinary ingredients, processed, or ultra-processed.

What does this study add?

- On average, UPF contributed just under half of total daily energy intake among Canadians both in 2004 (48%) and in 2015 (46%).
- Consumption of UPF was highest among children and adolescents. In these groups, UPF contributed over 50% of total daily energy in both survey years.
- The energy contributions of a number of UPF declined since 2004, particularly for soft drinks, fruit juices and fruit drinks.
- Among adults aged 55 or older, UPF contributed a greater share of total daily energy in 2015 compared with 2004.

Ultra-processed food and drink products (UPF) now dominate the food supply in high-income nations, including Canada, and their sales and consumption have been steadily increasing in lower-middle- and middle-income countries.[1-4] In 2016, per capita sales of UPF were estimated at 275 kg per year in Canada, the fourth highest among 80 countries.[4] Introduced a decade ago by researchers at Brazil's University of São Paolo, the concept of UPF refers food and drink products that are industrial formulations of mostly cheap sources of dietary energy and nutrients, along with additives. These products are manufactured using a series of processes (hence "ultra-processed") and contain few whole foods, if any.[5-6] Typical examples include soft drinks and other sugar-sweetened beverages, sweet and savoury packaged snacks, mass-produced industrial breads, reconstituted meat products such as burgers and hot dogs, and fast-food and frozen dishes. As a group, these products are characterized by convenience (i.e., durable, ready-to-eat), hyper-palatability, attractive packaging and extensive marketing.[3,6]

Diets high in UPF are typically high in nutrients of concern, including total energy, free sugars, saturated fats and sodium, and low in fibre, protein and micronutrients.[7-13] Mounting evidence from large-scale prospective studies from a number of countries has linked high UPF intake with elevated risk of several chronic conditions,[7,14] including cardiovascular disease[15,16] and type 2 diabetes,[17] as well as with premature death.[18] A recent randomized controlled trial found that an ultra-processed diet led to significantly increased energy intake and weight gain over a two-week period, compared with a non-ultra-processed diet.[19] In 2019, the revised Canada's Food Guide issued recommendations to limit the consumption of "highly processed foods and drinks" (defined as processed or prepared foods and drinks that contribute excess sodium, sugars or saturated fats to the diet) because they are not a part of a healthy eating pattern.[20]

According to the 2004 Canadian Community Health Survey (CCHS)-Nutrition, UPF contributed just under half of total daily energy to Canadian diets.[9] Whether or not patterns of UPF intake have changed in the following decade is unclear. The objective of this study was to characterize intakes of UPF among Canadians in 2015, both in terms of mean UPF intake and the distribution of usual UPF intake. This study used the most recent national dietary data available and compared the findings with 2004 estimates.

Data and methods

Data sources and analytic sample

Data for this study came from two population-representative cross-sectional surveys conducted by Statistics Canada: the 2004 CCHS-Nutrition (Cycle 2.2) and the 2015 CCHS-Nutrition. Canadian household residents of any age (2004) and those aged 1 or older (2015) living in the 10 Canadian provinces were the target populations of each survey.[21,22] Both surveys excluded full-time members of the Canadian Forces and persons who lived on reserves or in other Aboriginal settlements, in some remote areas, or in institutions. Each survey asked respondents to recall everything they ate and drank from midnight to midnight during the previous 24 hours, and to include detailed food descriptions and the amounts consumed.

The Automated Multiple Pass Method adapted for Canada was used in both surveys to help participants maximize their recall of the foods and drinks consumed. About 30% of respondents were selected to participate in a second 24-hour dietary recall 3 to 10 days after the initial interview. Data were mainly collected in person for the first recall and via telephone for the second recall.

The analytic sample of this study comprised respondents aged 2 years or older with a valid 24-hour dietary recall and with reported intake of greater than zero calories. Breastfeeding children were excluded because it is not possible to estimate total energy intake for this group. After exclusions (n=1,183 for 2004 and n=407 for 2015), the final analytic sample size was 33,924 for the 2004 survey and 20,080 for the 2015 survey.

The NOVA classification system

All food and drink items reported by respondents were classified according to NOVA (a name, not an acronym), an internationally recognized system of classifying foods by the extent and purpose of industrial food processing.[1,3,6,23] NOVA classifies foods into one of four groups: (1) unprocessed or minimally processed foods, (2) processed culinary ingredients, (3) processed foods, and (4) ultra-processed foods (UPF). Group 1 foods include fresh, dry and frozen fruits and vegetables; freshly squeezed fruit juice; fresh meat, poultry and seafood; milk and plain yogurt; eggs; legumes; pasta; and cereals and flour. Group 2 foods include culinary ingredients such as sugar, salt, butter and vegetables oils. Group 3 foods are made by adding culinary ingredients to Group 1 foods and include cheese; canned fruits and vegetables; salted, cured and canned meat or fish; and simple breads (e.g., artisanal bread, pita, naan, bannock). Finally, Group 4 foods are ultra-processed, and were the primary focus of this study. These foods were further categorized as mass-produced industrial breads and buns (including whole grain); reconstituted meat products (e.g., deli meat, hot dogs, sausages); soft drinks (including diet); commercial fruit juices and fruit drinks; confectionary (chocolate, candies, sweet desserts); sweetened or flavoured milk- and soy-based products (e.g., ice cream, flavoured yogurts); commercial cakes, cookies and pastries; chips, crackers and other salty snacks; sauces, spreads and salad dressings; margarine; sweetened breakfast cereals; commercial soups; and fast-food and frozen dishes.

Classification of food items according to NOVA

The classification of food items into NOVA groups proceeded in two phases, similar to previously published protocols,[9,13,24] and is summarized in Figure 1. In the initial phase, all basic foods and ingredients on the CCHS-Nutrition's Food and Ingredient Details file were classified into one of four mutually exclusive NOVA groups. Basic foods are foods that cannot be broken down into other food items (e.g., apple or 2% milk), or recipes without nutritional information available for the underlying ingredients (e.g., some granola bars).[22] Energy values (i.e., kcal) for each food item were based on the reported amount of food converted into gram weight, and were derived from the Canadian Nutrition File (CNF)-2015 for 2015 CCHS-Nutrition and, for the 2004 CCHS-Nutrition, from CNF version 2001b. Classification of food items into NOVA groups and subgroups was done based on food item description (not on nutrient profile) and followed previously published specifications.[6] The 2015 food items were classified first; identical or analogous food items from 2004 were automatically assigned the 2015 NOVA classification, leaving 650 food items to be classified manually.

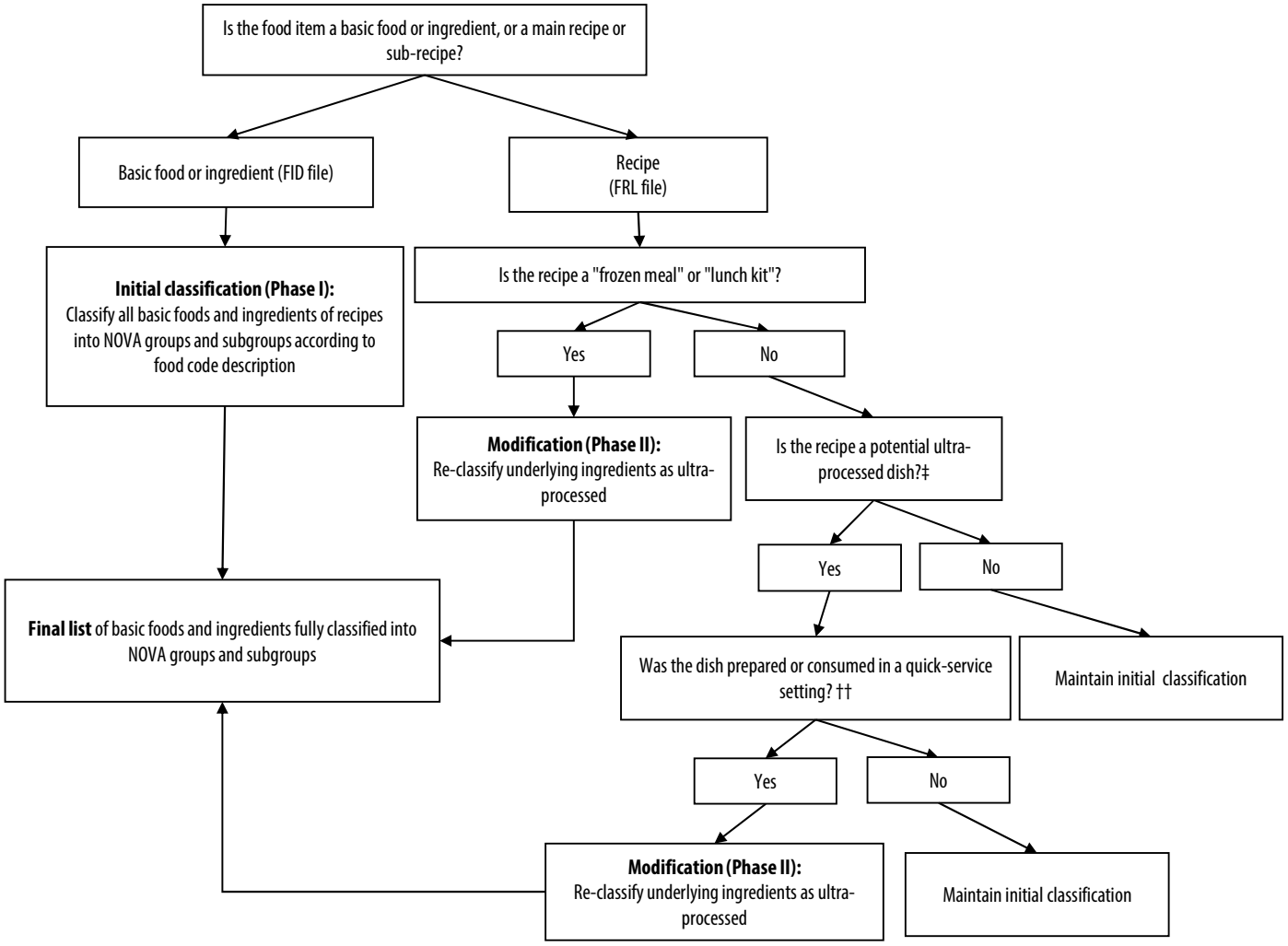
In the second phase, the Food Recipe Level file was searched to identify frozen meals, lunch kits and ultra-processed dishes in order to subsequently re-classify their underlying ingredients as ultra-processed (Figure 1). As a first step, a keyword search was conducted of common ultra-processed dishes (e.g., burger, pizza, sandwich) (Table 1). This list was not meant to be exhaustive and represents dishes most commonly consumed in quick-service settings, based on the survey data. Next, information on the consumption or preparation location of the flagged dishes was reviewed. In 2015, respondents were specifically asked about the location of food consumption.[22] If a flagged dish was consumed in a quick-service setting, then all of its underlying ingredients were re-classified as "fast-food and frozen dishes." In 2004, respondents were asked to report the location of food preparation if it was prepared anywhere other than home. However, some respondents reported the location of food consumption rather than of food preparation. Therefore, this variable represents a mix of the two concepts.[22] For 2004 data, an analogous approach to 2015 was applied for flagged dishes prepared or consumed in a quick-service setting. For both surveys, the initial ingredient-based classification was maintained if a flagged dish was prepared or consumed elsewhere (e.g., at home or at work). For example, if a hamburger was prepared or consumed in a fast-food restaurant, then all of its underlying ingredients (e.g., bun, meat patty, tomato, lettuce and condiments) were re-classified as ultra-processed. However, if the same hamburger was prepared or consumed at home, then the initial classification was maintained (i.e., bun and condiments categorized as UPF, and meat and vegetables as unprocessed or minimally processed). Lunch kit and frozen meal ingredients were re-classified as "fast food and frozen dishes" regardless of their place of consumption or preparation.

Two coauthors (J. Polsky and J.-C. Moubarac) independently classified food items according to NOVA; a small number of discrepancies were discussed and resolved.

Measure of UPF intake

UPF consumption was measured as the relative contribution of UPF to total daily energy intake, expressed as the percentage of total daily kilocalories from UPF.[25] Dietary energy from alcohol was excluded because alcoholic drinks are not immediately classifiable by NOVA.[6]

Figure 1
Classification of food items in the Canadian Community Health Survey (CCHS) - Nutrition 2004 and 2015 according to the NOVA system



‡ Recipes flagged as potential ultra-processed dishes using keywords.

†† For the 2015 CCHS-Nutrition, recipes consumed in the following settings were flagged for re-classification (variable FIDDCON): restaurant fast food/pizza; restaurant, no additional information; bar/tavern/lounge; sport or entertainement venue; car/other vehicle (only if food prepared outside the home). The following were flagged for the 2004 CCHS-Nutrition (variable FIDDDLOC): restaurant fast food/pizza; bar/tavern/lounge; take-out; vending machine; restaurant with no additional information.

FID file: Food and Ingredient Details file.

FRL file: Food Recipe Level file.

Source: Statistics Canada, Canadian Community Health Survey - Nutrition, 2004 and 2015.

Data analysis

Descriptive statistics were used to calculate the mean energy contribution of UPF overall and by UPF subgroup for the overall Canadian population and by age-sex group. Age-sex groups were defined based on key life course stages: young children (aged 2 to 5 years), children (aged 6 to 12), adolescent females and males (aged 13 to 18), adult females and males (aged 19 to 54), and older adult females and males (aged 55 or older). Only data from the first recall were used to estimate mean intakes, which are equivalent to mean usual (i.e., habitual) intakes at the population level.[26]

To estimate the distribution of the usual energy contributed by UPF, this analysis employed the univariate National Cancer Institute (NCI) method.[27,28] This method involves using data from both dietary recalls, allowing within-person day-to-day variability in food intake to be accounted for.[26] Because virtually all Canadians consumed some UPF in the previous day, the "amount only" model was used. Separate models were generated for each age-sex group, with both survey years pooled

Table 1
Keywords used to flag potential ultra-processed dishes in Phase II of NOVA classification

Keyword	Additional specifications
Biscuit	Only if part of a sandwich (e.g., breakfast sandwich)
Burger	…
Burrito	…
Calzone	…
Chicken	Selected types only: breaded/battered/coated (e.g., fried chicken finger or patty); chicken breast, fillet (typically part of chicken sandwiches)
Donut, doughnut	…
Fajita	…
French‡fried, fries	…
Frozen meal / dinner	…
Hash(ed) brown	…
Hot dog, hotdog	Vegetarian hot dogs included
Lunch‡kit, luncheable	…
Muffin	…
Nachos	…
Nugget	Chicken nuggets only
Onion ring	…
Pizza	Exclude dessert pizzas
Poutine	…
Quesadilla	…
Sandwich	Exclude nut butter sandwiches (e.g., peanut butter sandwich) and dessert sandwiches
Taco, tostada	…
Wing	Chicken wings only

… not applicable

‡ signifies wildcard character to allow for spelling variations.

Source: Statistics Canada, Canadian Community Health Survey - Nutrition, 2004 and 2015.

to provide more stable estimates of the variance components. All models adjusted for recall day (weekday or weekend), sequence of recall (first or second), survey cycle and the following sociodemographic covariates: world region of birth (North America; South America, Central America and the Caribbean; Asia; Europe; and other), highest household-level education (high school or less, some post-secondary, university degree or above), household income adequacy (quintiles of adjusted household income ratio to the low income cut-off), and household food security status (food secure, moderately insecure, severely insecure) as a complementary measure of economic vulnerability.

T-tests were used to assess differences between survey cycles in the mean proportion of energy from UPF. Analyses were conducted in SAS version 9.3 and SAS-callable SUDAAN v.11.0.1. Survey sampling weights were applied to account for the complex sampling design and unequal probability of selection. Bootstrap weights provided with each survey year were used to calculate robust standard errors. Statistical significance was flagged at three levels: * for $p<0.05$, ** for $p<0.001$ and *** for $p<0.0001$.

Sensitivity analyses

To account for the change in how the location of food preparation or consumption was measured between 2004 and 2015, as a sensitivity analysis, the mean energy contributions of UPF were compared across survey years based on only the initial phase of NOVA classification (i.e., a procedure that relies on more comparable data between cycles). Additionally, the proportion of Canadians who reported consuming selected common ultra-processed dishes (i.e., hot dogs, donuts, hamburgers, French fries) in the previous day were compared across years, regardless of the dish's location of preparation or consumption.

Self-reported dietary intakes are prone to misreporting (i.e., underreporting or overreporting of dietary intakes). Energy underreporting was indeed shown to be higher in the 2015 CCHS-Nutrition,[29] and there is concern that UPF may be differentially underreported because of social desirability bias.[30] Drawing comparisons within a comparable category of reporters (i.e., only plausible energy reporters) has been proposed as one potential solution to improve the quality of dietary intake comparisons over time.[29] Therefore, mean estimates of UPF intake were also generated by restricting the full sample to plausible energy reporters (n=12,770 in 2004 and n=8,244 in 2015), using a previously described methodology.[29]

Results

Energy intake by type of food processing

Table 2 presents mean proportions of daily energy intake according to NOVA's categories of food processing. At the national level, UPF contributed the largest share of total daily energy in both years (on average, 47.8% in 2004 and 45.7% in 2015), followed by unprocessed or minimally processed foods. Mean levels of UPF intake were highest among children and adolescents, contributing more than 50% of total daily energy in both years.

Since 2004, the dietary share of UPF declined by a small but significant amount overall and across most age-sex groups, except among adults aged 55 or older (Table 2). The largest decline was among adolescent females, with a drop of nearly 7 percentage points in the mean energy contributed by UPF. This was accompanied by higher energy contributions from unprocessed or minimally processed foods and from processed foods. In contrast, UPF contributed approximately 3 percentage points more in total energy among adults aged 55 or older in 2015 compared with 2004, while the energy contribution of unprocessed or minimally processed foods dropped by about 3 to 4 percentage points.

Table 2
Mean energy contribution (percent of total daily energy) according to NOVA group, by age and sex, household population aged 2 or older, Canada excluding territories, 2004 and 2015‡

	2004 n=33,924			2015 n=20,080		
		95% confidence interval			95% confidence interval	
Age-sex group (age in years)	%	from	to	%	from	to
NOVA 1: Unprocessed or minimally processed foods						
All ages	**38.9**	**38.5**	**39.4**	**39.4**	**38.8**	**40.0**
Young children, 2 to 5	38.3	37.2	39.3	41.0 *	39.3	42.6
Children, 6 to 12	33.4	32.6	34.1	35.1 *	34.1	36.2
Adolescent females, 13 to 18	32.3	31.2	33.3	36.2 **	34.3	38.0
Adolescent males, 13 to 18	32.3	31.3	33.3	34.5 *	32.9	36.2
Adult females, 19 to 54	40.2	39.4	41.1	41.7	40.5	42.9
Adult males, 19 to 54	39.0	37.9	40.1	39.7	38.2	41.1
Older females, 55 or older	44.0	42.8	45.1	39.6 ***	38.4	40.7
Older males, 55 or older	42.3	41.2	43.3	39.2 **	37.9	40.5
NOVA 2: Processed culinary ingredients						
All ages	**7.2**	**7.0**	**7.4**	**7.1**	**6.9**	**7.3**
Young children, 2 to 5	4.9	4.5	5.3	4.2 *	3.7	4.6
Children, 6 to 12	5.3	5.1	5.6	5.5	5.0	5.9
Adolescent females, 13 to 18	5.5	5.0	5.9	6.1	5.5	6.7
Adolescent males, 13 to 18	5.0	4.6	5.3	5.0	4.5	5.5
Adult females, 19 to 54	7.9	7.5	8.4	7.8	7.3	8.4
Adult males, 19 to 54	7.2	6.8	7.5	6.9	6.4	7.3
Older females, 55 or older	8.3	7.9	8.7	7.9	7.4	8.5
Older males, 55 or older	9.0	8.3	9.7	8.3	7.8	8.8
NOVA 3: Processed foods						
All ages	**6.1**	**5.9**	**6.3**	**7.8** ***	**7.5**	**8.1**
Young children, 2 to 5	5.8	5.2	6.5	6.9 *	6.1	7.6
Children, 6 to 12	5.5	5.2	5.9	6.4 *	5.9	6.8
Adolescent females, 13 to 18	5.1	4.6	5.5	7.3 ***	6.4	8.3
Adolescent males, 13 to 18	5.4	4.9	5.9	7.3 **	6.4	8.1
Adult females, 19 to 54	7.1	6.6	7.6	8.9 **	8.1	9.7
Adult males, 19 to 54	5.6	5.2	6.1	8.1 ***	7.3	8.8
Older females, 55 or older	6.0	5.5	6.5	7.3 *	6.5	8.0
Older males, 55 or older	6.2	5.7	6.7	7.3 *	6.4	8.1
NOVA 4: Ultra-processed foods						
All ages	**47.8**	**47.3**	**48.3**	**45.7** ***	**45.0**	**46.4**
Young children, 2 to 5	51.0	49.8	52.3	48.0 *	46.1	49.9
Children, 6 to 12	55.8	55.0	56.6	53.0 ***	51.9	54.2
Adolescent females, 13 to 18	57.2	56.1	58.3	50.4 ***	48.5	52.4
Adolescent males, 13 to 18	57.4	56.2	58.5	53.2 ***	51.5	54.9
Adult females, 19 to 54	44.8	43.8	45.8	41.6 **	40.2	43.0
Adult males, 19 to 54	48.2	47.0	49.4	45.4 *	43.8	47.0
Older females, 55 or older	41.7	40.6	42.8	45.2 ***	44.0	46.4
Older males, 55 or older	42.5	41.5	43.6	45.3 *	43.9	46.7

‡ Percentage of total daily energy (kcal) based on the first 24-hour recall.

* significantly different from 2004 ($p < 0.05$)

** significantly different from 2004 ($p < 0.001$)

*** significantly different from 2004 ($p < 0.0001$)

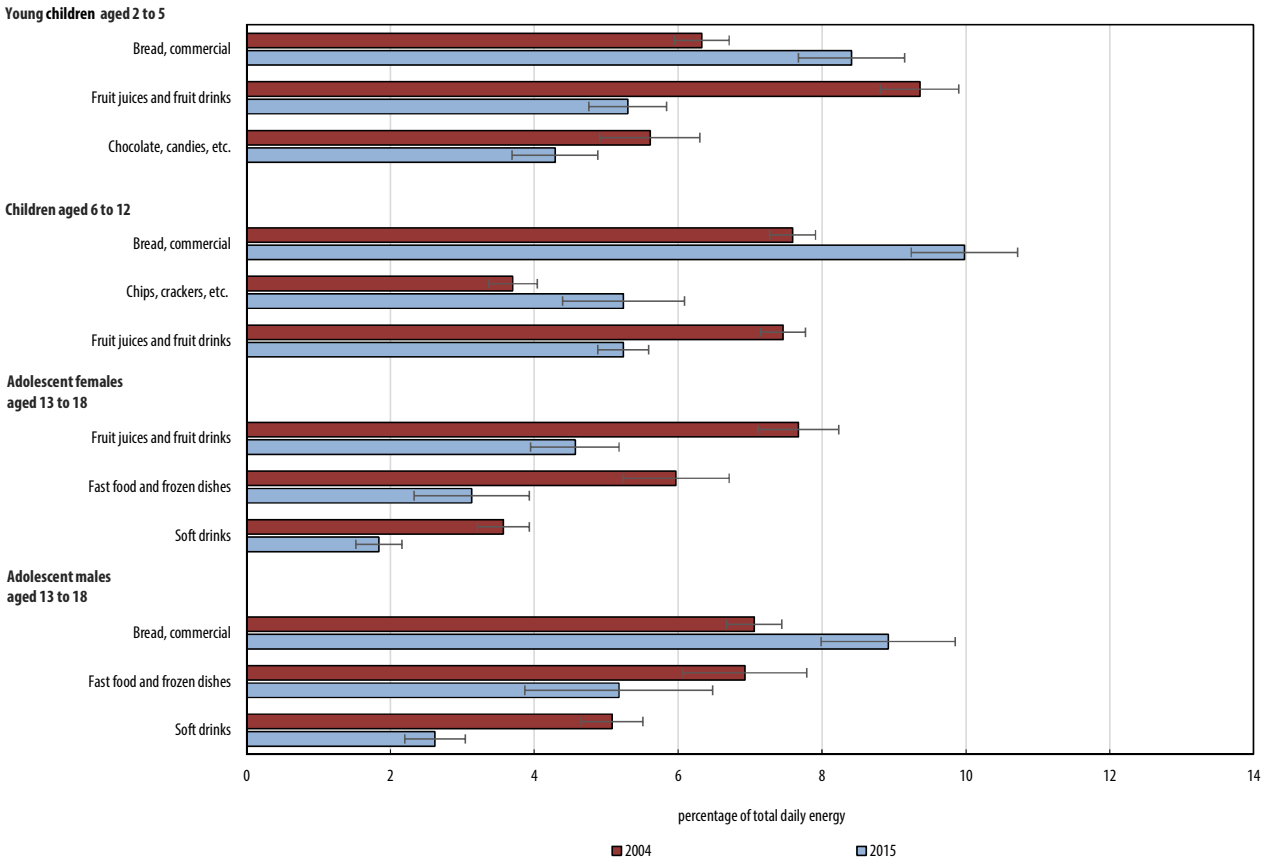
Source: Statistics Canada, Canadian Community Health Survey - Nutrition, 2004 and 2015.

The three UPF subgroups with the largest absolute differences in mean energy contribution between survey years are shown in Figure 2 for children and adolescents and in Figure 3 for adults. For children and adolescent females, fruit juices and fruit drinks contributed significantly less energy in 2015, whereas ultra-processed breads contributed substantially more energy for all children and adolescents (including adolescent females, data not shown) (Figure 2). Bread intake was also substantially higher in 2015 for adults of all ages (Figure 3). In contrast, the energy contributions of fast-food and frozen dishes decreased by 1.5 to 2.5 percentage points for adults aged 19 to 54, but increased by 1.5 percentage points for males aged 55 or older. At the national level, bread was the leading source of UPF intake in both years, increasing from 7.8% (standard error, SE: 0.1%) of total daily energy in 2004 to 10.1% (SE: 0.1%) in 2015 ($p<0.0001$). The energy contributions of other UPF subgroups decreased slightly from 2004 to 2015: for example, the energy contribution of fast-foods and frozen dishes decreased from 5.0% (SE: 0.2%) of total daily energy to 3.6% (SE: 0.2%); for soft drinks, from 2.7% (SE: 0.1%) to 1.7% (SE: 0.1%); and for fruit juices and fruit drinks, from 4.9% (SE: 0.1%) to 3.6% (SE: 0.1%) (all p-values for comparisons <0.0001).

Usual intakes of UPF

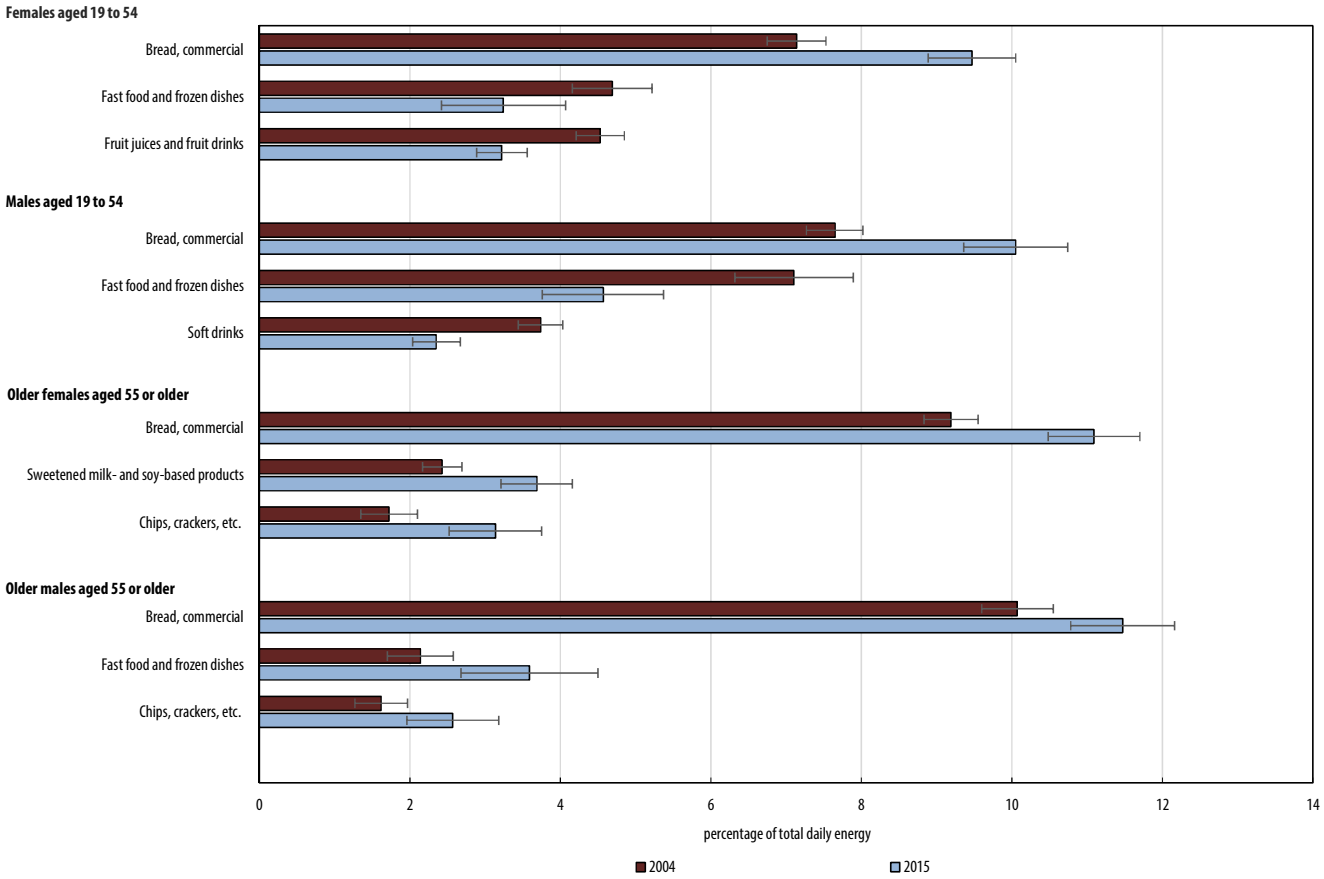
Among the overall Canadian population, the usual energy contributed by UPF was persistently high in both survey years, although it has shifted downward since 2004: for example, the median proportion of usual energy intake from UPF was 47.0% (SE: 0.2%) in 2004, compared with 44.9% (SE: 0.4%) in 2015. There is currently no published guidance on optimal levels of UPF intake. Using the arbitrary threshold of 50% of total energy coming from UPF in a typical day, 59.7% (SE: 0.8%) of Canadians had intakes below this threshold in 2004 compared with 65.8% (SE: 1.1%) in 2015 ($p<0.0001$). Similar patterns of lower usual UPF intake in 2015 were seen among children and

Figure 2
Mean energy contributed by UPF subgroups, by age and sex, household population aged 2 to 18, Canada excluding territories, 2004 and 2015‡



‡ For each age-sex group, the figure shows the three ultra-processed food and drink (UPF) subgroups with the largest absolute change between 2004 and 2015 in the mean percentage of total daily energy intake from UPF.
Notes: Estimates are mean percentages of total daily energy from UPF and error bars are associated 95% confidence intervals. These are based on the first 24-hour recall. All 2015 estimates are significantly different from 2004 ($p < 0.05$).
Source: Statistics Canada, Canadian Community Health Survey - Nutrition, 2004 and 2015.

Figure 3
Mean energy contributed by UPF subgroups, by age and sex, household population aged 19 or older, Canada excluding territories, 2004 and 2015‡



‡ For each age-sex group, the figure shows the three ultra-processed food and drink (UPF) subgroups with the largest absolute change between 2004 and 2015 in the mean percentage of total daily energy intake from UPF.
Notes: Estimates are mean percentages of total daily energy from UPF and error bars are associated 95% confidence intervals. These are based on the first 24-hour recall. All 2015 estimates are significantly different from 2004 ($p < 0.05$).
Source: Statistics Canada, Canadian Community Health Survey - Nutrition, 2004 and 2015.

adolescents (Figure 4) and younger adults (Figure 5). For adults aged 55 or older, the distribution shifted upward, indicating higher usual intake of UPF in 2015 (Figure 5). Although median intake of UPF was lowest among adults aged 55 or older in 2004 (contributing approximately 42% of total usual energy), this was no longer the case in 2015. In 2015, the lowest median usual intake of UPF was observed among females aged 19 to 54 (contributing 41.4% of total usual energy, SE: 0.7%).

Sensitivity analyses

Analyses based only on the initial (Phase I) classification of ingredients and basic foods resulted in findings that were highly consistent with those of the main analysis. Using this approach, the mean energy contribution of UPF among the overall population was estimated at 45.6% of total daily energy in 2004 and 44.1% in 2015 (p=0.0003). Age- and sex-specific patterns were also in line with the main analysis, showing slightly lower intakes of UPF in 2015 than in 2004 for all age-sex groups, except for adults aged 55 or older (data not shown). Additionally, slightly fewer Canadians reported consuming selected ultra-processed dishes (i.e., hot dogs, burgers, donuts and French fries) during the previous day in 2015 than in 2004, regardless of these foods' place of preparation or consumption, with some exceptions among older adults (data not shown). Finally, analyses restricted to plausible energy reporters produced a pattern of findings that was highly consistent with results based on the full sample (data not shown).

Discussion

As in 2004, the energy contribution of UPF in Canadian diets remained high in 2015. On average in 2015, UPF contributed 46% of total daily energy for the overall population and more than 50% for children and adolescents. Despite these persistently high levels of UPF consumption, the share of total energy from UPF declined slightly since 2004 overall and among children, adolescents and younger adults, although with some variation across subgroups of UPF. In contrast, UPF

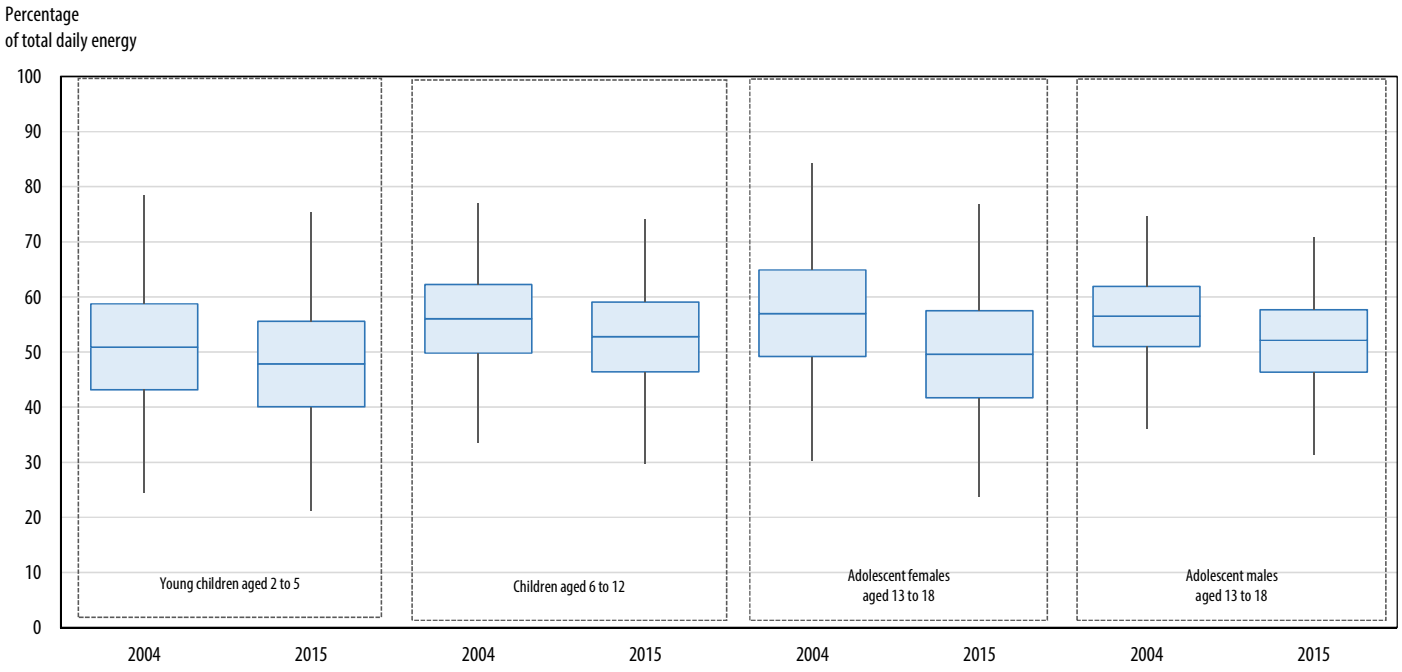
contributed more energy for adults aged 55 or older. These patterns were unchanged when analyses were restricted to plausible energy reporters.

The slight decline in the dietary share of UPF among most age-sex groups is consistent with international trends in food and drink sales. These trends document a slight but significant decrease in the volume of UPF sales in Canada and other high-income nations since the early 2000s.[1,4,31] The overall decline since 2004 in the energy share of UPF observed in this study was heavily driven by lower energy contributions from fruit juices, fruit drinks and soft drinks. Declining trends in the consumption of fruit juices and other sugar-sweetened beverages over the past decade, particularly among children and younger adults, have been documented in multiple analyses of national-level dietary intake data.[31-34]

Despite the small overall decline, the energy contributions of some types of UPF increased. Most notably, consumption of mass-produced packaged breads (the top UPF energy contributor in both years) and, to a lesser extent, salty snacks including chips and crackers increased among some age-sex groups. The increased contribution of breads to daily energy intake was consistent across all age-sex groups. Mass-produced breads were similarly reported as top sources of UPF in United States, United Kingdom and Australia, also ranking as the fifth leading source of added sugars in the U.S. diet.[10,35,36] Commercially produced breads are among the top contributors to total energy and sodium in Canadian diets.[37]

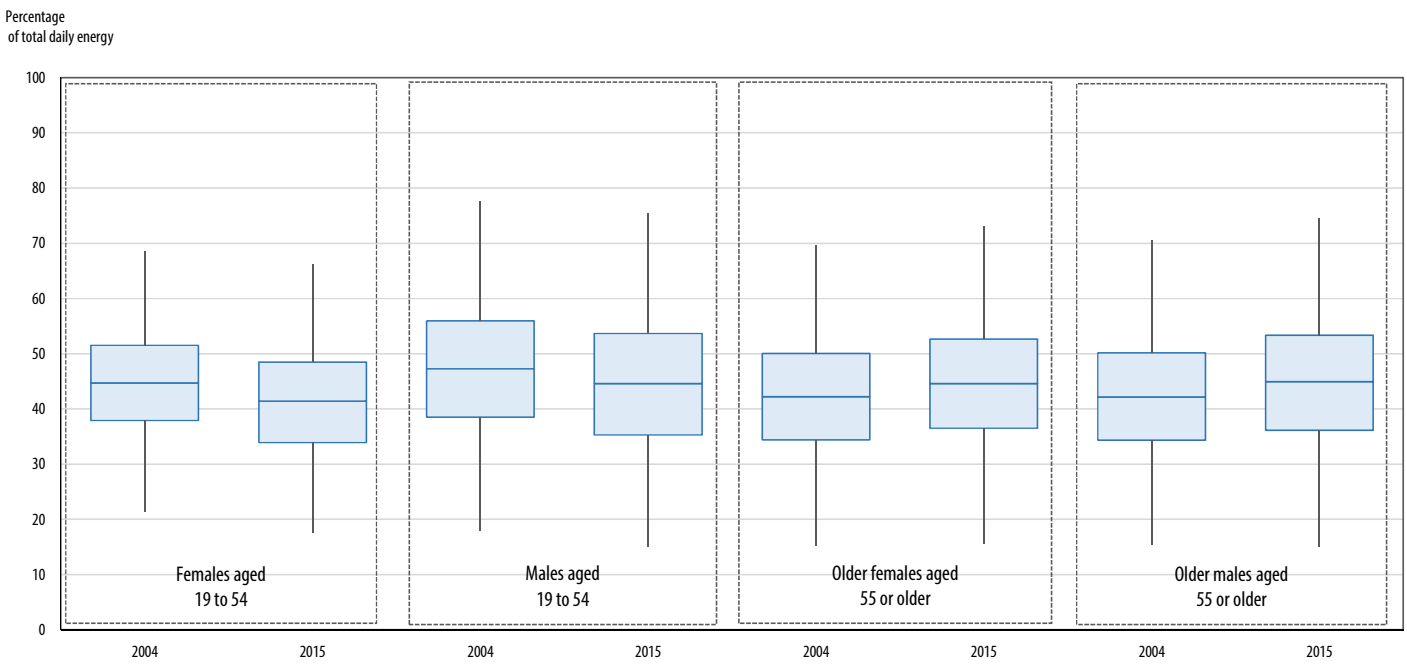
Compared with 2004, this study documented a higher share of energy from UPF among adults aged 55 or older in 2015, alongside lower energy contributions from unprocessed or minimally processed foods. These findings are unexpected given that older Canadians have historically consumed higher quality diets than younger adults,[38] including consuming less fast food.[39] While no reports exist to draw direct comparisons, recent analyses of CCHS-Nutrition data showed that older adults were the only age group to consume significantly more calories from high-fat and/or high-sugar foods in 2015 compared with 2004,[40] and were the group with the widest gap between reported and recommended intakes of fruits and vegetables.[34] An analysis using a composite measure of diet quality found that while diet quality has generally improved since 2004 for Canadian children and adults, this trend was reversed for females aged 55 to 64 and males aged 65 to 74.[41] Collectively, these findings signal potentially deteriorating diet quality among older Canadians, and therefore warrant further examination.

Figure 4
Distribution of usual energy contributed by UPF, by age and sex, household population aged 2 to 18, Canada excluding territories, 2004 and 2015‡



UPF: Ultra-processed foods and drinks.
‡ Estimates calculated using the National Cancer Institute method and adjusted for world region of birth, household-level education, household income adequacy, household food security status, weekday or weekend of record, sequence of recall, survey cycle, and sex of children under the age of 13.
Note: Values of each box plot represent the 99th percentile (top whisker), 75th percentile (top edge of box), 50th percentile (middle line on box), 25th percentile (bottom edge of box), and 1st percentile (bottom whisker).
Source: Statistics Canada, Canadian Community Health Survey - Nutrition, 2004 and 2015.

Figure 5
Distribution of usual energy contributed by UPF, by age and sex, household population aged 19 or older, Canada excluding territories, 2004 and 2015‡



UPF: Ultra-processed foods and drinks.
‡ Estimates calculated using the National Cancer Institute method and adjusted for world region of birth, household-level education, household income adequacy, household food security status, weekday or weekend of record, sequence of recall, survey cycle, and sex of children under the age of 13.
Note: Values of each box plot represent the 99th percentile (top whisker), 75th percentile (top edge of box), 50th percentile (middle line on box), 25th percentile (bottom edge of box), and 1st percentile (bottom whisker).
Source: Statistics Canada, Canadian Community Health Survey - Nutrition, 2004 and 2015.

The high levels of UPF intake estimated in this study are in line with previously reported estimates based on population-representative nutrition data from Canada and other high-income nations, which range from 42% of total energy intake in Australia to 57% to 58% in the United Kingdom and United States.[9,10,35,36] The persistently high intakes of UPF across all age-sex groups in Canada, particularly among children and adolescents, is concerning given the mounting evidence that diets high in UPF are associated with poorer overall diet quality,[7-13] weight gain,[19] and increased risk of a range of diet-related conditions.[7,14-17] A recent one-month randomized controlled trial compared the impact of minimally processed and ultra-processed ad-libitum diets while matching the diets for presented calories, energy density and macronutrients (sugar, fat and protein), as well as for sodium and fibre.[19] Results showed that ultra-processed diets led to rapid weight gain, suggesting effects beyond nutrient composition, although researchers did not take into account the types of nutrients (e.g., naturally occurring vs. free sugars).

Aside from nutrient composition, the exact mechanisms by which diets high in UPF confer negative health effects have yet to be elucidated, but may involve the low satiety potential and high glycemic response of UPF,[42] as well as changes to the gut microbiome that disturb energy balance and promote inflammation.[43,44] Cosmetic additives commonly used in UPF manufacturing (e.g., flavours, emulsifiers, thickeners) and contact materials migrating from food packaging (e.g., phthalates, bisphenol A) have also been implicated in adverse health effects.[45-47] Additional research is needed to investigate the mechanisms of action and relative effects of different aspects of UPF on health (e.g., nutrient composition, additives, packaging material).

Strengths and limitations

Strengths of this study include the use of two large surveys that are representative of the 10 Canadian provinces and employ similar methodology and sampling designs. The CCHS-Nutrition data represent the most robust and recent available data on the dietary intakes of Canadians. The classification of foods according to NOVA was done rigorously and systematically, which optimized the quality of comparisons between cycles. Unlike previous studies of population-level UPF intakes, which predominantly draw on data from a single dietary recall, this study also used data from the second dietary recall to adjust for within-person variation in day-to-day food intake. This allowed the estimation of how the distribution of usual energy contributed by UPF changed over time, in addition to changes in the mean energy contribution of UPF.

Several limitations deserve mention. As with all self-reported dietary data, it is common for respondents to misreport food and

drink intakes; underreporting is particularly common. To improve the quality of comparisons between survey cycles, analyses were repeated for a subsample of plausible energy reporters. These analyses revealed results that were highly consistent with the main analysis. Additionally, the 2015 CCHS-Nutrition used a new food model booklet that depicted generally smaller standard amounts than in the booklet used in 2004, particularly for bowls, glasses and mugs.[22] This change may have affected the comparability of estimates across survey years, particularly for some types of beverages.[33] However, not all beverages were reported using the food model booklet, and a significantly smaller proportion of Canadians reported consuming any fruit drinks and soft drinks on the previous day in 2015 compared with 2004.[33] There is currently no standard approach to quantify any underestimation that may have resulted from changes to the food model booklet.

The CNF database that provides food code descriptions and energy values changed from 2004 to 2015, and may have provided different nutrient profiles for certain foods or beverages. Changes to the CNF can reflect the evolution of food products available in the marketplace (e.g., product reformulation) or database changes (e.g., amalgamation of certain food codes). Additionally, some food items may have been misclassified into NOVA groups because of insufficient information in food code descriptions on processing and a lack of brand-specific information.

Finally, estimates of fast food consumption in both survey years are likely underestimated because the CCHS-Nutrition data do not allow fast-food dishes consumed outside of food service settings (i.e., takeout or delivery) to be reliably identified. Because of changes to content on the location of food consumption or preparation in the 2015 survey, comparisons of fast food intake between survey cycles should also be done with caution. These changes may have resulted in greater underestimation of fast food consumption outside of food service settings in 2015 data than in the 2004 data. Despite this, sensitivity analyses based only on disaggregated food codes, as well as an examination of selected fast-food dishes, regardless of where they were prepared or consumed, revealed patterns that were highly consistent with the main analyses.

Conclusion

As in 2004, the overall dietary share of UPF in Canada remained high in 2015. However, intakes of some UPF types, particularly beverages, declined. The share of energy from UPF has remained highest among children and adolescents, and increased among adults aged 55 or older. These findings provide valuable data on Canadians' intakes of UPF, particularly given the mounting evidence that high UPF consumption has a negative impact on diet quality and health. While no specific guidance currently exists on optimal levels (i.e., thresholds) of UPF intake, distributions of usual UPF intake estimated in this study can be used to assess alignment with any future guidance of this type.

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