Restaurant foods: when sodium goes out, what goes in? A longitudinal study

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Abstract:	Background: Restaurant foods have high sodium levels and efforts have been made to promote reductions. The objective of this study was to understand if salt substitutes are being used to lower sodium levels in restaurant foods. Methods: A longitudinal database (MENU-FLIP) containing nutrition information for Canadian chain restaurants with ≥20 locations nationally was created in 2010 and updated in 2013 and 2016. In 2016, when available, ingredient lists were collected from restaurant websites and searched for the presence of salt substitutes. Changes in sodium levels (per serving) and the prevalence of salt substitutes in 222 unique foods from 12 of the leading fast-food restaurant chains were compared across three time points. Results: Sixty-nine percent of foods contained a salt substitute. Salt substitutes were found in every restaurant (n=12) for which ingredient data was available. The most common substitutes were yeast extracts (in 30% of foods), calcium chloride (28%), monosodium glutamate (14%) and potassium chloride (12%). Foods that contained salt substitutes decreased by a significantly higher amount of sodium (190±42 mg per serving) when compared to foods that did not contain a salt substitute (40±17 mg per serving, $p<0.001$). Interpretation: Salt substitutes are prevalent in restaurant foods, and are one means by which restaurants are lowering sodium levels in their foods. At this point in time, the potential consequences of these findings, if any, are uncertain.

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Author Contributions:

Dr. Scourboutakos and Dr. L'Abbé had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Scourboutakos and L'Abbé conceived and designed the study; Scourboutakos, Murphy and L'Abbé acquired the data; Scourboutakos analyzed and interpreted the data; Scourboutakos wrote the manuscript; Scourboutakos, Murphy and L'Abbé reviewed the manuscript for important intellectual content; L'Abbé obtained funding and supervised the study.

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ABSTRACT

Introduction: Restaurant foods have high sodium levels and efforts have been made to promote reductions. The objective of this study was to understand if salt substitutes are being used to lower sodium levels in restaurant foods.

Methods: A longitudinal database (MENU-FLIP) containing nutrition information for Canadian chain restaurants with ≥20 locations nationally was created in 2010 and updated in 2013 and 2016. In 2016, when available, ingredient lists were collected from restaurant websites and searched for the presence of salt substitutes. Changes in sodium levels (per serving) and the prevalence of salt substitutes in 222 unique foods from 12 of the leading fast-food restaurant chains were compared across three time points.

Results: Sixty-nine percent of foods contained a salt substitute. Salt substitutes were found in every restaurant (n=12) for which ingredient data was available. The most common substitutes were yeast extracts (in 30% of foods), calcium chloride (28%), monosodium glutamate (14%) and potassium chloride (12%). Foods that contained salt substitutes decreased by a significantly higher amount of sodium (190±42 mg per serving) when compared to foods that did not contain a salt substitute (40±17 mg per serving, p<0.001).

Conclusions: Salt substitutes are prevalent in restaurant foods, and are one means by which restaurants are lowering sodium levels in their foods. At this point in time, the potential consequences of these findings, if any, are uncertain.

BACKGROUND

Excessive dietary sodium intake is a causal risk factor for hypertension,(1) which is the leading preventable risk factor for death worldwide.(2) Research has shown that 27% of dietary sodium comes from food obtained at restaurants.(3) This is partly due to the increased prevalence of eating outside-the-home,(4-8) along with the excessive sodium levels commonly found in restaurant foods.(9-11)

In response to the high sodium levels in restaurant foods, efforts such as the US National Salt Reduction Initiative,[12, 13] and the FDA's reduction targets have been established to promote reductions in sodium.(12-14) In Canada, sodium reduction targets have been set for packaged foods, but not yet for restaurant foods.(15) However, several restaurant chains have made voluntary commitments to lower sodium.(11, 16-18)

It has been recommended that the best strategy to lower sodium is to gradually reduce levels across the food supply to enable consumers' taste-buds to re-sensitize to less salt.(12, 19, 20) Salt substitutes (such as potassium chloride, monosodium glutamate, and yeast extracts) are one means by which sodium can be removed without reducing the perceived salty taste.(19, 21)

The market share for salt substitutes such as monosodium glutamate (MSG), yeast extracts and hydrolyzed vegetable proteins is currently on the rise.(22) MSG and other ingredients that could contain free glutamates (such as yeast extracts and hydrolyzed vegetable protein) are desirable substitutes because they stimulate the fifth taste bud—umami.(23)

Furthermore, when compared to table salt, MSG contains one-third the amount of sodium, thus enabling sodium reductions as high as 40%, with no loss of palatability.(24)

That being said, MSG has been a controversial ingredient since 1968 when the so-called "Chinese Restaurant Syndrome" was first reported to include numbness at the back of the neck and arms, as well as palpitations and weakness.(25) Since then a number of studies have investigated the effect of MSG on a variety of symptoms (including headache, nausea, flushing, dizziness, burning, perspiration, chest pain/pressure, muscle pain and insulin secretion) with mixed results.(26-39) These mixed findings were likely due to the fact that many early studies were anecdotal,(25, 40, 41) had small sample sizes,(29-32, 36) tested a wide range of doses (varying from 1.25 to 10 grams),(26, 39) administered MSG in a variety of food contexts (ie non-caloric beverages versus whole meals), [24,](29, 30, 33, 35) (42, 43) and were confounded by the fact that some individuals are sensitive to MSG, while others are not.(26) (28, 32, 34, 39)

To date, no studies have investigated the prevalence of salt substitutes in restaurant foods. The first objective of this study was to investigate the prevalence of salt substitutes in restaurant foods. The second objective was to understand if the presence of salt substitutes is associated with lower sodium levels in restaurant foods. The third objective was to determine if glutamate-containing substitutes (MSG, yeast extracts and hydrolyzed vegetable proteins) are associated with lower sodium levels in restaurant foods.

METHODS

Data for this study was derived from the MENU-FLIP University of Toronto restaurant nutrition database. This study was the third in a series of longitudinal studies that have investigated changes in sodium levels in Canadian chain restaurant foods every three years using the MENU-FLIP database.(44, 45)

MENU-FLIP database

In 2010, a database of Canadian chain restaurant foods (MENU-FLIP) was created using publically available nutrition information provided online by all chain restaurants that had ≥20 locations nationally.(46) According to the 2010 *Directory of Restaurant and Fast-Food Chains in Canada*, 172 restaurants had >20 locations nationally.(47) After searching websites, 95 provided nutrition information online. Data for over 9000 a la carte entrées, side dishes, beverages, and condiments were collected and complied into the database. Foods were categorized according to the type of restaurant (fast-food versus sit-down), the specific restaurant they are from (ie McDonalds, Subway; subsequently referred to as the "restaurant variable"), the type of food (ie hamburger, sandwich, chicken, french fries; subsequently referred to as the "food category" variable) and the type of food item (ie entrée, side dish, kids' item). Additional details describing the database can be found elsewhere.(46)

In 2010, 4044 entrées, side dishes, and kids' meals were analyzed in the baseline report.(44) In May 2013, restaurant websites were revisited and data was recollected.(45) When available, the updated nutrient information collected in 2013 was matched to the existing product data from 2010. In 2013 data for 2198 of the same foods were matched across the two time points. When previous data had not been collected for a particular food item, the food was labeled as being a “new product”. In May 2016, this process was repeated. Data collected in 2016 was entered and matched by one author (SAM). Another author (MJS) double-checked data entry and matches. In addition, range and logic checks were conducted and 10% of the dataset was verified against the original source by a third-party data checker.

After sodium levels (per serving) in 2016 were subtracted from sodium levels (per serving) in 2010, foods were coded as having “increased”, “decreased” or “stayed the same”.This was subsequently converted into a binary “decrease versus didn’t decrease” variable that distinguished between foods whose sodium level decreased versus foods that did not decrease (increased/stayed the same). Among foods whose sodium level decreased, a numerical “magnitude of decrease” variable as calculated by subtracting 2010 sodium levels (per serving) from 2016 levels.

Inclusion/exclusion criteria

Of the 95 restaurants that provided information, thirty-four were excluded from the 2013 follow-up analysis because they provided incomplete data, details are reported elsewhere.(45) An additional 8 restaurants were excluded from the 2016 follow-up for the following reasons: they stopped providing information online (n=2), they no longer provided serving size information (n=3), they only provided data for beverages/baked goods (n=3).

The following foods were excluded from this analysis: foods that are not a major source of dietary sodium (beverages, baked goods, desserts and ice cream), appetizers (because portion sizes varied widely from two to ten servings), sauces and condiments (they were not consistently reported), meals that reported data for entrées in combination with side dishes (only individual, a la carte, menu items were analyzed), foods for which serving size or sodium information was unavailable, size duplications, and foods in categories that had less than 10 items.

Ingredient information procurement

Ingredient information was collected from restaurant websites in 2016. The list of salt replacements in Appendix D of the Institute of Medicine’s “Strategies to Reduce Sodium Intakes” was used to identify potential salt substitutes.(19) Ingredient lists were searched for all substitutes listed in the report (**supplementary table 1**). When a food contained a salt substitute, this information was entered into the MENU-FLIP database. Each salt substitute was coded separately as a binary (yes/no) variable. Two additional aggregate variables were also created: “salt substitute” (a binary yes/no variable to indicate what foods contained any salt substitute) and “glutamate-containing substitutes” (a binary yes/no variable to indicate which foods contained monosodium glutamate, OR hydrolyzed vegetable protein OR yeast extracts). According to the aforementioned IOM report, hydrolyzed vegetable protein and yeast extracts “often contain MSG”.(19) A complete list of ingredient names that were considered to potentially contain MSG can be found in **supplementary table 1**.

Statistical Analysis

The proportion of foods that contained any substitute, each substitute, and glutamate-containing substitutes was tabulated and stratified across foods that decreased versus did not decrease.

Chi-square tests were used to assess the association between containing a "salt substitute" and whether a food decreased in sodium per serving (the "decrease versus did not decrease" variable). This test was repeated for each substitute and the "glutamate-containing substitutes" variable.

Among the sub-set of foods whose sodium level decreased, the non-parametric Wilcoxon-Mann-Whitney test was used to compare the median magnitude of decrease in foods that contained a salt substitute versus foods that did not contain a salt substitute. Comparisons of the magnitude of decrease were computed overall, and stratified by food category.

All statistical analyses were conducted using SAS version 9.3 software (SAS Institute Inc. Cary, NC).

RESULTS

The analysis included a total of 666 foods (222 unique foods) from 12 of the leading fast-food restaurants in Canada. The following chains were included: A&W, Arby's, Burger King, Edo Japan, Kentucky Fried Chicken, McDonald's, Pizza Pizza, Pizza 73, Subway, Taco Del Mar, Taco Time and Tim Hortons. The sample encompassed 84% of outlets from the top ten restaurant chains in Canada. This included 11,333 outlets, representing 39% of all chain-restaurant outlets across Canada.

Prevalence of salt substitutes

Sixty-nine percent of foods contained a salt substitute. Yeast extracts were the most common salt substitute found in 30% of foods (**figure 1**), followed by calcium chloride (in 28% of foods), monosodium glutamate (in 14% of foods), potassium chloride (in 12% of foods), hydrolyzed vegetable proteins (in 8% of foods) and lactates (in 4% of foods).

Salt substitutes were found in every restaurant (n=12) for which ingredient data was available. More than 50% of chicken, cheeseburgers and sandwiches/wraps (often chicken and turkey sandwiches) contained salt substitutes, while 100% of tacos/burritos, stir fry entrées, and pizza slices contained salt substitutes (**figure 2**).

Association between salt substitutes and magnitude of decrease in sodium

Sixty-four percent of the foods that contained a salt substitute decreased in sodium (mg per serving) between 2010 and 2016. Foods that contained a salt substitute decreased by a significantly higher amount of sodium (190±42 mg per serving) compared to foods that did not contain a salt substitute (40±17 mg per serving, $p<0.001$) (**figure 3**). This trend was seen in all analyzable food categories and was significant in hamburgers and cheeseburgers ($p<0.001$).

Glutamate-containing substitutes

Salt substitutes that contain or often contain free glutamates (MSG, yeast extracts, and hydrolyzed vegetable proteins) were found in 53% of foods. 70% of foods that had a glutamate-containing substitute decreased in sodium between 2010 and 2016 and were significantly more likely to have decreased in sodium ($p=0.0345$) compared to foods that did not have a glutamate-containing substitute. Foods with glutamate-containing substitutes had a significantly higher magnitude of decrease (190±39 mg/serving) compared to foods that did not have a glutamate containing substitute (60±51 mg/serving, $p<0.001$).

Glutamate-containing substitutes were found in nearly every restaurant (except one) that provided ingredient information. Eighty-percent of chicken menu-items (including battered/ fried chicken, and breaded chicken strips) contained MSG (**figure 2**).

INTERPRETATION

The results of this study suggest that salt substitutes are being used to help achieve sodium reductions in fast-food restaurants. 69% of foods contained salt substitutes. Furthermore, foods that contained salt substitutes decreased by a significantly higher amount of sodium when compared to foods that did not contain salt substitutes.

MSG

MSG was found in 14% of foods investigated in this study and was particularly prevalent in fast-food chicken products. MSG is considered a safe food additive,(48) however, according to the International Classification of Headache Disorders, MSG (or more specifically, free glutamate) can be a causative trigger of headaches in healthy populations, and especially in migraine sufferers.(49) MSG is believed to elicit symptoms because of the free (unbound) glutamate that it contains. Glutamate is the most ubiquitous excitatory neurotransmitter in the body(50) and has been demonstrated to play a critical role in headache pathophysiology in animal models and human studies.(29, 30, 51-57) However, whether or not dietary glutamate consumed in the context and amounts currently found in meals can elicit symptoms is controversial.

It should be noted that glutamate is present in many foods.(58) While some foods contain glutamate in its free form (including ripe tomatoes [172 mg per medium tomato] and parmesan cheese [120 mg per two tablespoons]), most naturally occurring dietary glutamate is bound to other amino acids (unlike MSG) and is thus slowly metabolized and less likely to elicit symptoms.(58)

Previous studies have detected a dose-response when MSG is administered at increasing levels.(26-28) One study suggested that the threshold for reactivity may be 2.5 grams,(26) and anecdotally reported that a highly seasoned restaurant meal could provide as much as 5 grams of MSG. At this time, the dosage of MSG in restaurant foods is unknown as levels have never been formally investigated or reported. Therefore, no conclusion can be made regarding whether the current dosage in fast-foods has potential to elicit symptoms.

Context-dependent effects of MSG

MSG may have different effects depending on the context in which it is consumed. Animal models have proposed that a spike in plasma glutamate is the mechanism by which glutamate causes symptoms.(59, 60) Research has shown that when MSG is consumed on its own (ie administered in a calorie-free beverage) it causes a peak plasma concentration of glutamate one hour after ingestion.(43) However, when MSG is ingested with carbohydrates, measurable plasma concentrations of glutamate are not achieved.(61) Similarly, one of the largest studies of MSG concluded that symptoms are only present when large doses are given without food.(27) However, it should be noted that other studies have detected symptoms when MSG was administered with tomato juice,(28) or in the context of a lunch meal.(33) In this study, MSG was found in a variety of food categories (ranging from chicken to sandwiches to soup) with varying levels of accompanying carbohydrate. Hence, potential effects from the MSG detected in this study could be mitigated by the food context. Thus, before warnings or recommendations can be made regarding the presence of MSG in the restaurant food supply, more research is needed to understand the extent to which food context mitigates the effect of MSG.

Hydrolyzed vegetable proteins and yeast extracts

The results showed that yeast extracts were the most common salt substitute found in restaurant foods. Yeast extracts often contain free-glutamate,(19) but may also contain glutamate bound to other amino acids. Therefore, the exact amount of free-glutamate in yeast extracts is unknown. Thus, even if the amount of yeast extract in restaurant foods was quantified, the dosage of free-glutamates in these foods would still be uncertain. Furthermore, there is no research investigating symptoms resulting from yeast extract consumption. Hence, inferences cannot be made as to whether these additives could elicit the symptoms that MSG has been associated with. Thus, considering the prevalence of yeast extracts in the food supply, there is a need for more research on these substitutes.

Limitations

The small sample (n=222) of foods for which ingredient information was available and the lack of longitudinal data on the prevalence of salt substitutes prior to 2016 are limitations of this study. Hence, this study demonstrates associations between salt substitutes and sodium level (per serving), but does not prove that salt substitutes have been added to achieve sodium reductions. Many restaurant foods are constantly introduced or removed from menus, therefore, the results of this study only include foods that have persisted on menus between 2010 and 2016.

Ingredient data were only available for fast-food chains; therefore, it is unknown whether the findings in this study would be applicable to sit-down restaurant chains and independent restaurants. In addition, our dataset only represents restaurants that provided nutrition and ingredient information online.

Research on MSG is highly controversial. Susceptibility to MSG-related symptoms varies from person to person and depends on dose, amount and food source. Hence, future research is needed to determine the exact dose of MSG and free glutamates in restaurant foods. Therefore, at this point in time, conclusions cannot be drawn regarding whether or not the current MSG-dosage present in restaurant foods is sufficient to elicit symptoms. Hence, the potential consequences of these findings, if any, are uncertain.

Conclusion

Salt substitutes are prevalent in restaurant foods and may be a means by which restaurants are responding to calls to lower sodium. More research is needed to understand the implications of these findings.

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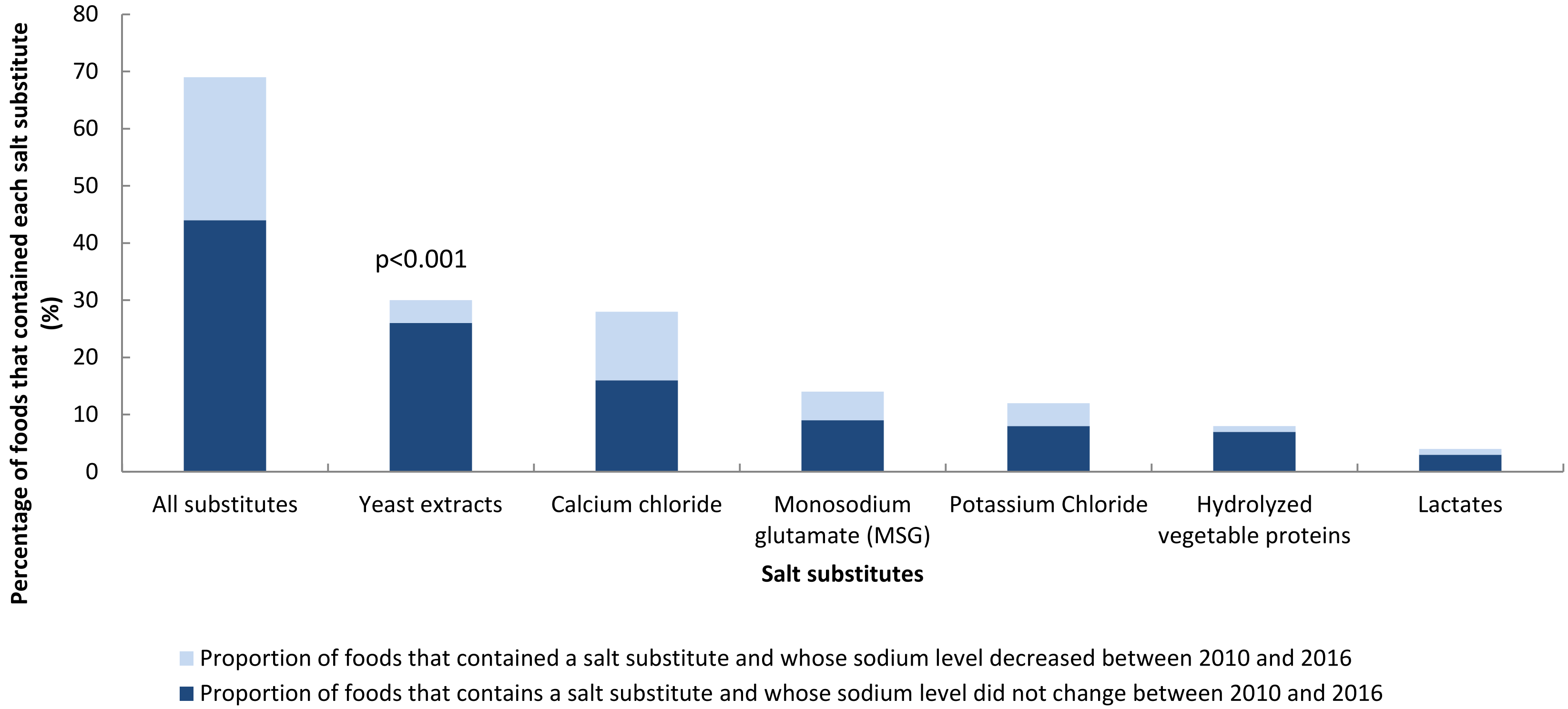
FIGURE TITLES

Figure 1 – Percentage of fast-food items that contained each substitute and comparison of the proportion that decreased versus did not decrease in sodium per serving

Figure 2 – Proportion of fast-food items that contained salt substitutes, by type

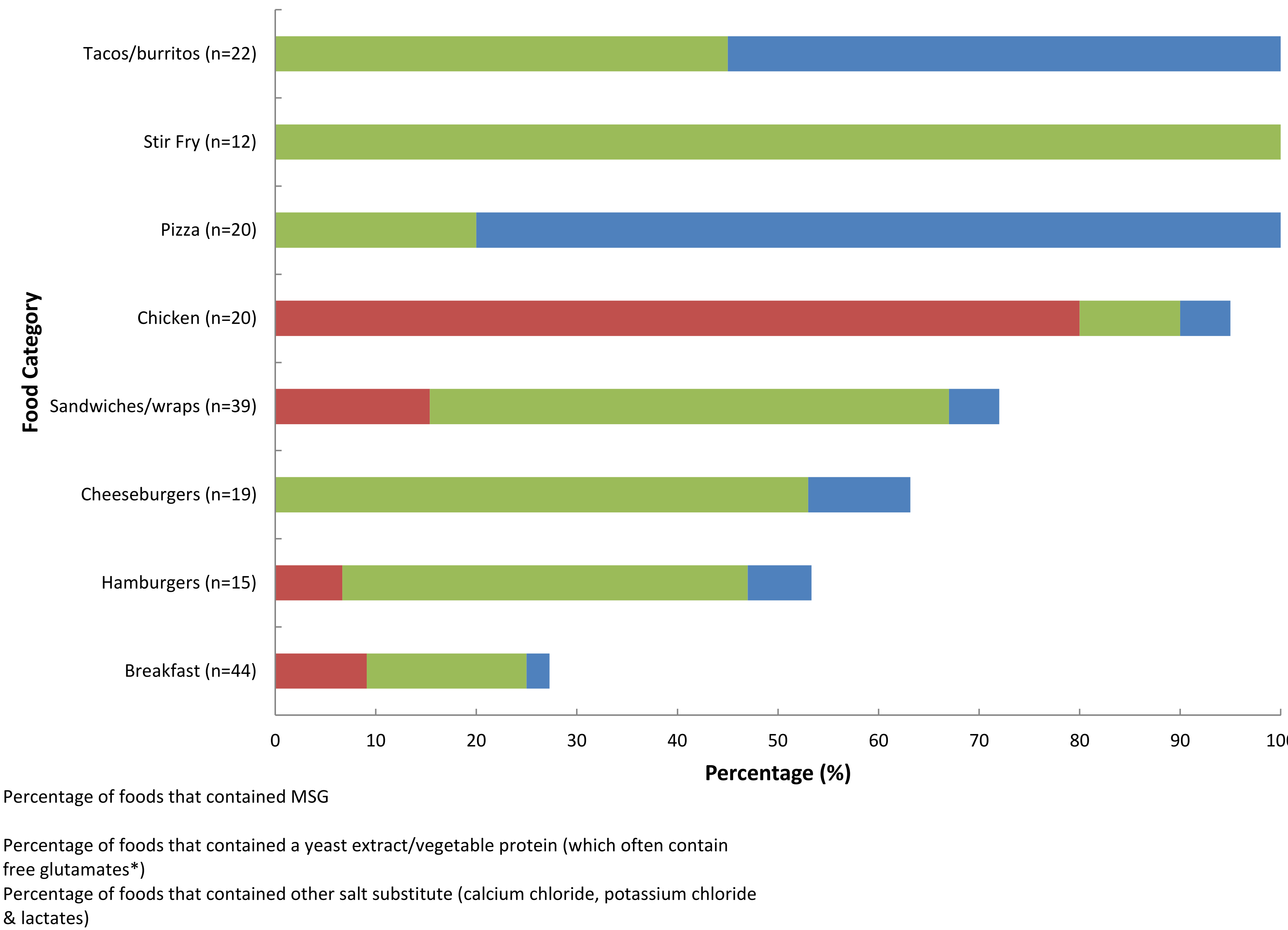
Figure 3 – Magnitude of decrease in sodium (mg/serving) among fast-food items that contained a salt substitute versus foods that did not contain a salt substitute

Figure 1 – Percentage of fast-food items that contained each substitute and comparison of the proportion of foods that decreased versus did not decrease in sodium per serving



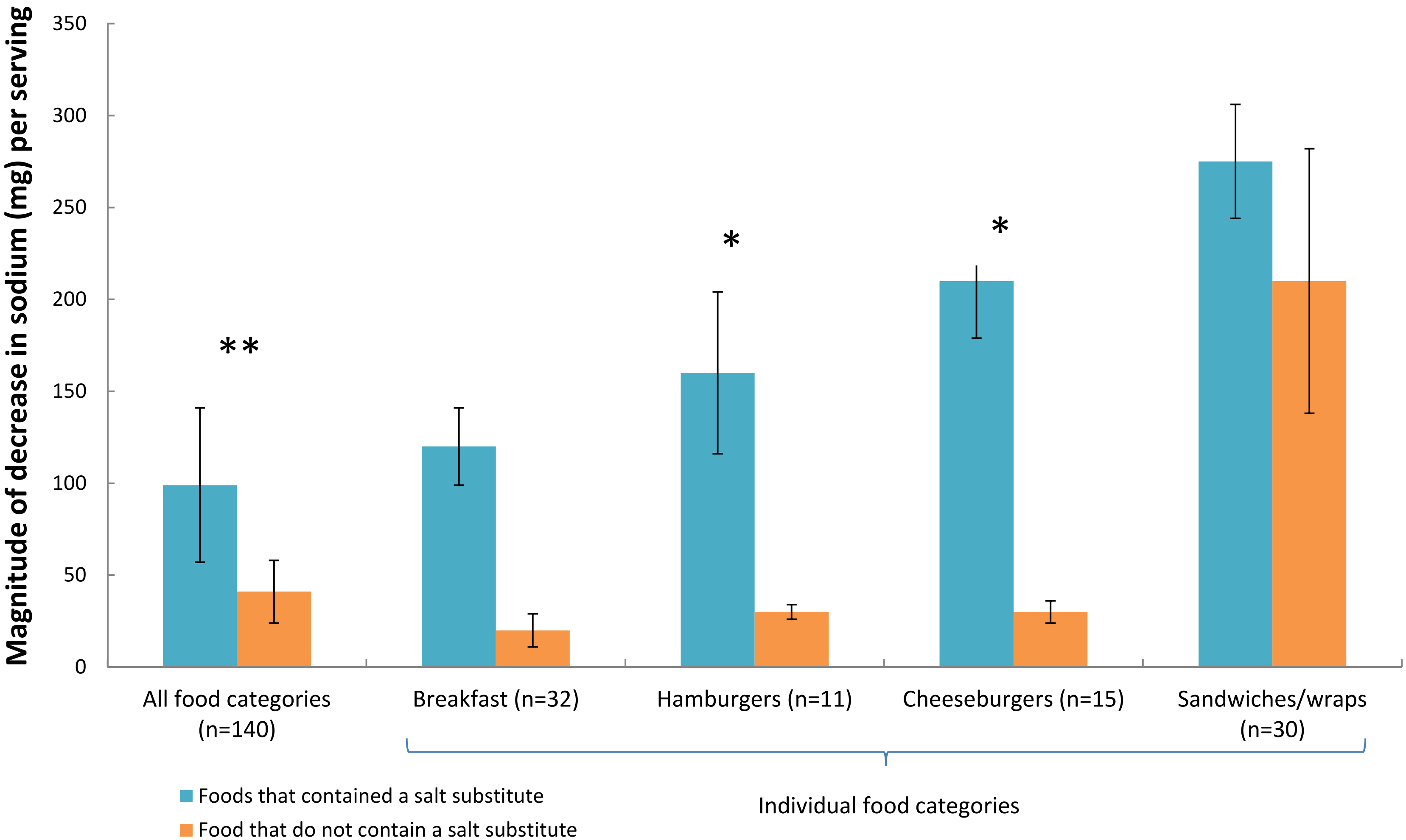
p-value represent chi-square tests comparing the association between containing a the respective salt substitute and likelihood of having decreased in sodium (mg per serving) between 2010 and 2016
Salt substitutes were identified using the “Strategies to Reduce Sodium Intake in the United States” report (Appendix D) published by the Institute of Medicine (IOM)(19)

Figure 2 – Proportion of fast-food items that contained salt substitutes, by type



*Yeast extracts and hydrolyzed vegetable proteins "often contain MSG" according to the "Strategies to Reduce Sodium Intake" report published by the Institute of Medicine(19)

Figure 3 – Magnitude of decrease in sodium (mg/serving) among fast-food items that contained a salt substitute versus foods that did not contain a salt substitute



Bars represent median ± standard errors
*p=0.01, **p<0.001, non-parametric Wilcoxon-Mann-Whitney tests

"All food categories" includes (breakfast, cheeseburgers, chicken, hot dogs, hamburgers, kids' meals, fries, pizza, poutine, salad entrées with meat, sandwiches/wraps, mashed potatoes, rice, soup, tacos/burritos)

Only categories with >10 foods were presented individually in this graph

Supplementary Table 1 List of salt substitutes

Salt substitutes[a]	Details/specific names that were searched for	Found in the restaurant food supply
Potassium chloride (KCl)		yes
Calcium chloride ($CaCl_2$)		yes
Magnesium chloride ($MgCl_2$)		no
Magnesium sulfate ($MgSO_4$)		no
Salts with altered crystal structure	The prevalence of this substitute could not be assessed in this study	Unknown
Monosodium glutamate (MSG) and other glutamates	Monosodium glutamate (E 621), glutamic acid (E 620) , glutamate (E 620), monopotassium glutamate (E 622), calcium glutamate (E 623), monoammonium glutamate (E 624), magnesium glutamate (E 625), natrium glutamate, Umami, Ajnimoto, Vetsin	yes
Yeast extracts and hydrolyzed vegetable proteins	Hydrolyzed yeast protein, hydrolyzed vegetable protein, hydrolyzed yeast extract, yeast extract, torula yeast, autolyzed yeast, autolyzed plant protein, soy sauce, soy sauce extract, any "hydrolyzed protein"	yes
Nucleotides	Inosine-5'monophosphate (IMP), guanosin-5'-monophosphate	no
Amino acids	Especially arginine	no
Lactates	Potassium lactate, calcium lactate, sodium lactate	yes
Compounds that reduce bitterness	Adenosine-5'-monophosphate, DHB (2,4-dihydrozybenzoic acid), sodium gluconate	no

[a]This list of salt substitutes was derived from Appendix D of the Institute of Medicine's report on "Strategies to reduce sodium intakes in the United States"(19)

Table 1. STROBE-nut: An extension of the STROBE statement for nutritional epidemiology

Lachat C et al. (2016) STrengthening the Reporting of OBservational studies in Epidemiology – Nutritional Epidemiology (STROBE-nut): an extension of the STROBE statement. Plos Medicine 13(6) http://dx.doi.org/10.1371/journal.pmed.1002036 pdf or online version.

Item	Item nr	STROBE recommendations	Extension for Nutritional Epidemiology studies (STROBE-nut)	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract. (b) Provide in the abstract an informative and balanced summary of what was done and what was found.	**nut-1** State the dietary/nutritional assessment method(s) used in the title, abstract, or keywords.	2
Introduction				
Background rationale	2	Explain the scientific background and rationale for the investigation being reported.		2/3
Objectives	3	State specific objectives, including any pre-specified hypotheses.		3
Methods				
Study design	4	Present key elements of study design early in the paper.		3/4
Settings	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection.	**nut-5** Describe any characteristics of the study settings that might affect the dietary intake or nutritional status of the participants, if	3/4

Item	Item nr	STROBE recommendations	Extension for Nutritional Epidemiology studies (STROBE-nut)	Reported on page #
			applicable.	
Participants	6	a) Cohort study—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up. Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls. Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants. (b) Cohort study—For matched studies, give matching criteria and number of exposed and unexposed. Case-control study—For matched studies, give matching criteria and the number of controls per case.	**nut-6** Report particular dietary, physiological or nutritional characteristics that were considered when selecting the target population.	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.	**nut-7.1** Clearly define foods, food groups, nutrients, or other food components. **nut-7.2** When using dietary patterns or indices, describe the methods to obtain them and their nutritional properties.	3/4

Item	Item nr	STROBE recommendations	Extension for Nutritional Epidemiology studies (STROBE-nut)	Reported on page #
Data sources - measurements	8	For each variable of interest, give sources of data and details of methods of assessment (measurement).Describe comparability of assessment methods if there is more than one group.	**nut-8.1** Describe the dietary assessment method(s), e.g., portion size estimation, number of days and items recorded, how it was developed and administered, and how quality was assured. Report if and how supplement intake was assessed. **nut-8.2** Describe and justify food composition data used. Explain the procedure to match food composition with consumption data. Describe the use of conversion factors, if applicable. **nut-8.3** Describe the nutrient requirements, recommendations, or dietary guidelines and the evaluation approach used to compare intake with the dietary reference values, if applicable. **nut-8.4** When using nutritional biomarkers, additionally use the STROBE Extension for Molecular Epidemiology (STROBE-ME). Report the type of biomarkers used and their usefulness as dietary exposure markers. **nut-8.5** Describe the assessment of nondietary data (e.g., nutritional status and influencing factors) and timing of the assessment of these variables in relation to	3/4

Item	Item nr	STROBE recommendations	Extension for Nutritional Epidemiology studies (STROBE-nut)	Reported on page #
			dietary assessment. **nut-8.6** Report on the validity of the dietary or nutritional assessment methods and any internal or external validation used in the study, if applicable.	
Bias	9	Describe any efforts to address potential sources of bias.	**nut-9** Report how bias in dietary or nutritional assessment was addressed, e.g., misreporting, changes in habits as a result of being measured, or data imputation from other sources	7
Study Size	10	Explain how the study size was arrived at.		4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why.	**nut-11** Explain categorization of dietary/nutritional data (e.g., use of N-tiles and handling of nonconsumers) and the choice of reference category, if applicable.	4/5
Statistical Methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions. (c) Explain how missing data were addressed. (d) Cohort study—If applicable, explain how loss to follow-up was addressed.	**nut-12.1** Describe any statistical method used to combine dietary or nutritional data, if applicable. **nut-12.2** Describe and justify the method for energy adjustments, intake modeling, and use of weighting factors, if applicable. **nut-12.3** Report any adjustments for measurement error, i.e,. from a validity or	5

Item	Item nr	STROBE recommendations	Extension for Nutritional Epidemiology studies (STROBE-nut)	Reported on page #
		Case-control study—If applicable, explain how matching of cases and controls was addressed. Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy. (e) Describe any sensitivity analyses.	calibration study.	
Results				
Participants	13	(a) Report the numbers of individuals at each stage of the study—e.g., numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analyzed. (b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram.	**nut-13** Report the number of individuals excluded based on missing, incomplete or implausible dietary/nutritional data.	3/4
Descriptive data	14	(a) Give characteristics of study participants (e.g., demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing data for each variable of interest (c) Cohort study—Summarize follow-up time	**nut-14** Give the distribution of participant characteristics across the exposure variables if applicable. Specify if food consumption of total population or consumers only were used to obtain results.	3/4

Item	Item nr	STROBE recommendations	Extension for Nutritional Epidemiology studies (STROBE-nut)	Reported on page #
		(e.g., average and total amount)		
Outcome data	15	Cohort study—Report numbers of outcome events or summary measures over time. Case-control study—Report numbers in each exposure category, or summary measures of exposure. Cross-sectional study—Report numbers of outcome events or summary measures.		N/A
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included. (b) Report category boundaries when continuous variables were categorized. (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period.	**nut-16** Specify if nutrient intakes are reported with or without inclusion of dietary supplement intake, if applicable.	5
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions and sensitivity analyses.	**nut-17** Report any sensitivity analysis (e.g., exclusion of misreporters or outliers) and data imputation, if applicable.	6

Item	Item nr	STROBE recommendations	Extension for Nutritional Epidemiology studies (STROBE-nut)	Reported on page #
Discussion				
Key results	18	Summarize key results with reference to study objectives.		6
Limitation	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	**nut-19** Describe the main limitations of the data sources and assessment methods used and implications for the interpretation of the findings.	7
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	**nut-20** Report the nutritional relevance of the findings, given the complexity of diet or nutrition as an exposure.	6/7
Generalizability	21	Discuss the generalizability (external validity) of the study results.		
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based.		1
Ethics			**nut-22.1** Describe the procedure for consent and study approval from ethics committee(s).	N/A
Supplementary material			**nut-22.2** Provide data collection tools and data as online material or explain how they can	16

Item	Item nr	STROBE recommendations	Extension for Nutritional Epidemiology studies (STROBE-nut)	Reported on page #
			be accessed.	