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Change in Trans Fatty Acid Content of Fast-Food Purchases Associated With New York City's Restaurant Regulation

A Pre–Post Study

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Background: Dietary trans fat increases risk for coronary heart disease. In 2006, New York City (NYC) passed the first regulation in the United States restricting trans fat use in restaurants.

Objective: To assess the effect of the NYC regulation on the trans and saturated fat content of fast-food purchases.

Design: Cross-sectional study that included purchase receipts matched to available nutritional information and brief surveys of adult lunchtime restaurant customers conducted in 2007 and 2009, before and after implementation of the regulation.

Setting: 168 randomly selected NYC restaurant locations of 11 fast-food chains.

Participants: Adult restaurant customers interviewed in 2007 and 2009.

Measurements: Change in mean grams of trans fat, saturated fat, trans plus saturated fat, and trans fat per 1000 kcal per purchase, overall and by chain type.

Results: The final sample included 6969 purchases in 2007 and 7885 purchases in 2009. Overall, mean trans fat per purchase decreased by 2.4 g (95% CI, −2.8 to −2.0 g; $P < 0.001$), whereas saturated fat showed a slight increase of 0.55 g (CI, 0.1 to 1.0 g; $P = 0.011$). Mean trans plus saturated fat content decreased by 1.9 g overall (CI, −2.5 to −1.2 g; $P < 0.001$). Mean trans fat per 1000 kcal decreased by 2.7 g per 1000 kcal (CI, −3.1 to −2.3 g per 1000 kcal; $P < 0.001$). Purchases with zero grams of trans fat increased from 32% to 59%. In a multivariate analysis, the poverty rate of the neighborhood in which the restaurant was located was not associated with changes.

Limitation: Fast-food restaurants that were included may not be representative of all NYC restaurants.

Conclusion: The introduction of a local restaurant regulation was associated with a substantial and statistically significant decrease in the trans fat content of purchases at fast-food chains, without a commensurate increase in saturated fat. Restaurant patrons from high- and low-poverty neighborhoods benefited equally. However, federal regulation will be necessary to fully eliminate population exposure to industrial trans fat sources.

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Cardiovascular disease is the leading cause of death in the United States, and risk is increased by poor diet. Trans fatty acid (trans fat) and saturated fatty acid (saturated fat) intake negatively affect serum cholesterol profiles, thus increasing risk for cardiovascular disease; however, the relative effect of trans fat is worse (1, 2). An increase of just 2% of total energy intake from trans fat increases the incidence of coronary heart disease by as much as 23% (1). Dietary trans fat has both naturally occurring and industrially produced sources. By the late 1990s in the United States, most trans fat in the diet (79%) came from processed oils and fats, most commonly from partially hydrogenated vegetable oil (3). Because of the increased risk for cardiovascular disease conferred by trans fat intake and because industrial sources of trans fat can be replaced with more healthful alternatives, many countries and localities have recently introduced policies that decrease trans fat intake by prompting its removal from the food supply. In 2003, Denmark became the first country to introduce regulatory limits on the trans fat content of foods sold (4). In Canada and the United States, nutritional labeling of trans fat content became required on packaged foods in 2005 and 2006, respectively (5, 6). In 2006, New York City (NYC) became the first locality in the United States to pass a regulatory restriction on the use of partially hydrogenated vegetable oil, targeting the restaurant environment. This latter approach is important because more than one third of daily calorie intake in the United States is from food prepared away from home (7).

The NYC regulation was phased in starting in July 2007 and was fully in effect by July 2008. It restricts all food service establishments, including both chain and nonchain restaurants, from using, storing, or serving food that contains partially hydrogenated vegetable oil and has a total of 0.5 g or more trans fat per serving. Trans fat restrictions for restaurants have since been adopted by at least 15 additional local and state jurisdictions (8). These policies represent important public health innovations with broad-scale potential to enable patients to achieve complicated dietary changes, such as avoiding trans fat intake, commonly recommended by health care providers.

Evaluating the effect of these policies on trans fat content and intake is paramount, especially as countries and jurisdictions around the world continue to introduce similar actions (9, 10). Such an assessment should address

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Context

A restriction on restaurant sale of foods containing trans fats went into effect in New York City in 2008.

Contribution

In 2007 and 2009, receipts were obtained from adult customers exiting fast-food chain restaurants in New York City and matched to published nutritional information. Between these 2 periods, there was a substantial decrease in the amount of trans fat purchased per meal, without a commensurate increase in saturated fat. Results did not differ according to the poverty rate of the neighborhood in which the restaurant was located.

Caution

Only national chain restaurants were studied.

Implication

Regulation can result in positive dietary change at the population level.

—The Editors

concerns that restricting trans fat use could lead to replacing saturated fat at an amount that offsets the benefit of trans fat reduction (11). Since the introduction of trans fat labeling in Canada and food content restrictions in Denmark, studies of changes in total trans plus saturated fat or trans fat content in packaged food thus far have been generally favorable (4, 12). In NYC, statistically significant decreases in trans fat and trans plus saturated fat content in French fries were found at chain restaurants after full implementation of the restaurant restriction (97.9% and 54.2% decreases, respectively) (13). An analysis of 83 major brand-name U.S. supermarket and restaurant foods, which were reformulated to reduce trans fat content, found that saturated fat levels were lower than or similar to prereformulation levels in 65% of supermarket products and 90% of restaurant products assessed (14). These studies of marketplace product availability are important because they assess changes in consumer options. However, a more complete assessment of intake would consider both product availability, as prepared for consumption, and consumer choice. Although restaurants would provide an ideal setting to conduct such an evaluation, to our knowledge no studies to date have considered the change in trans fat content of restaurant purchases as a result of trans fat regulations.

To evaluate the effect of the NYC restaurant trans fat regulation on trans fat intake as reflected by food purchases, we used a unique survey data set of customers of lunchtime chain restaurants fielded before and after full implementation of the trans fat regulation. The data set was initially collected to assess NYC's calorie-labeling regulation, but it included information on nutrients in addition to calories (15, 16). We aimed to describe and compare trans fat, saturated fat, and trans plus saturated fat content in lunchtime purchases intended for individual consumption before and after implementation of the regulation, including consideration of the effect of associated sociodemographic variables. We hypothesized that the trans fat and trans plus saturated fat content of lunchtime purchases would decrease after the NYC regulation that restricted the use of trans fat in restaurants was implemented.

METHODS

Study Design

In 2007, we randomly sampled 300 locations from all 1625 NYC licensed restaurant locations of 13 chains. These 13 chains represented almost 90% of all eligible restaurants, defined as chain restaurants that have more than 15 locations nationally, have available nutritional information, and are not ice cream chains. Of the 300 identified restaurant locations, 25 were excluded because they had closed or were in an airport or a shopping mall.

For 9 weeks from March through June 2007, we recruited patrons exiting the 275 sampled fast-food locations for participation in the study. They were asked to provide their receipts after exiting and to take a brief survey to describe their purchase, confirm that it was for only 1 person, and answer a few additional questions. During the same time frame in 2009, we approached the same restaurant locations for a repeated survey of patrons. Of the original 275 locations, 22 had either closed or would not allow data collection and were therefore replaced in our sample by outlets of the same chain in the same neighborhood or a neighboring ZIP code. The NYC Department of Health and Mental Hygiene Institutional Review Board determined the study to be exempt from review.

Study Population

Study participants included adults entering sampled fast-food chains between noon and 2:00 p.m. during the survey time frames. We offered a single-ride MetroCard as an incentive. We based the patron sample size calculation for the original calorie study on the assumptions of a coefficient of variation of 38% in purchased calories and a design effect of 4. The study therefore required at least 3600 people per year for an 80% power to detect a 5% change in calories between 2007 and 2009. To allow for stratified analyses of that study, we set a goal of 10 000 customer receipts for each study period. Sampling and data collection methodology have been published previously (15).

Because this study aimed to assess lunchtime purchases, we excluded data from patrons of the 2 coffee chains in the original list of 13 chains. Our analysis therefore included purchases from patrons of 168 locations of 11 fast-food chains in NYC. These include hamburger chains (McDonald's, Burger King, Wendy's), sandwich chains (Subway, Au Bon Pain), fried chicken chains (KFC,

Popeyes), pizza chains (Domino's, Pizza Hut, Papa John's), and a Mexican food chain (Taco Bell).

Data Set

The final data set included items purchased plus modifications made to each item at the customer's request, the sex of the customer, and the customer's intention for individual consumption. We matched baseline receipts from 2007 and receipts collected in 2009 after the regulation was implemented to nutritional information posted on company Web sites on 1 March 2007 and 1 March 2009, respectively. Of note, federal regulations allow products that contain up to 0.5 g of trans fat to be labeled as containing "zero" grams of trans fat.

Receipts were deemed ineligible for inclusion if the purchase was for more than 1 person, the customer's order could not be determined, or the customer did not order a food item. We also excluded receipts with missing calorie, trans fat, or saturated fat information for at least 1 food item.

Statistical Analysis

Our analysis compared purchases made in 2007 and 2009 that were intended for individual consumption and contained at least 1 food item. Using the SURVEYMEANS procedure in SAS, version 9 (SAS Institute, Cary, North Carolina), to account for the clustered sample design, we calculated descriptive statistics (mean [±SE] and range) for the number of grams of trans fat, saturated fat, trans plus saturated fat, and trans fat per 1000 kcal for purchases (overall and by chain type) for both years.

We performed hypothesis testing separately for each measure of fat purchased by using the SURVEYREG procedure (a regression procedure that accounts for complex survey design) in SAS. We estimated the unadjusted differences in mean saturated and trans fat per purchase between 2007 and 2009 and tested them against the null hypothesis of no change. Multiple linear regression modeling estimated the adjusted change in mean grams of trans fat per purchase from 2007 to 2009, controlling for customer sex, the poverty rate of the neighborhood in which the restaurant was located, calories purchased, and individual chain. For this model, purchases with missing data in any variable were excluded. We included calories in the model to control for changes in the size of menu items between the 2 study periods. We controlled for the variation in the number of customers by chain between 2007 and 2009 by including indicator (dummy) variables for each chain. Neighborhood poverty rate was based on the restaurant's ZIP code and is the percentage of households below 200% of the national poverty level. All analyses were conducted by using SAS, version 9.

Role of the Funding Source

The 2007 baseline data collection was funded by the City of New York. The follow-up data collection was funded by the City of New York and the Robert Wood Johnson Foundation Healthy Eating Research Program to examine the effectiveness of calorie labeling. Staff supervising and analyzing the study of trans fat content were employees of the NYC Department of Health and Mental Hygiene.

RESULTS

Lunchtime receipts and surveys totaled 7750 in 2007 and 8730 in 2009. We excluded 589 receipts from 2007 because of ineligibility and 192 because of missing calorie or fat information in a food item; for 2009, we excluded 557 and 288, respectively. Foods missing calorie or fat information were generally limited-time offers, rather than items on the regular menu. Our final analytic sample totaled 14 854 purchases (6969 from 2007 and 7885 from 2009). In both years, customers were evenly split between men and women. The distribution of customers by chain type also remained similar, with 53% from hamburger chains, 28% from sandwich chains, 12% from fried chicken chains, and approximately 4% each from pizza and Mexican food chains.

Between 2007 and 2009, mean trans fat content per purchase decreased by 2.4 g (2.9 vs. 0.5 g; 95% CI, −2.8 to −2.0 g [$P < 0.001$]) (**Table 1**). Trans fat content per purchase showed a statistically significant decrease from 2007 to 2009 in 3 of the 5 chain types and an increase in 1. The greatest absolute decrease per purchase (3.8 g) was observed in hamburger chains (4.5 vs. 0.7 g; CI, −4.2 to −3.5 g [$P < 0.001$]), followed by Mexican food and fried

Table 1. **Change in Trans Fat Content in Lunchtime Purchases at New York City Fast-Food Chains**

Chain Type	Receipts, *n*		Mean Trans Fat Content (±SE), *g*		Change (95% CI), *g*	*P* Value	Mean Trans Fat Content (±SE), *g/1000 kcal*		Change (95% CI), *g/1000 kcal*	*P* Value
	2007	2009	2007	2009			2007	2009		
All receipts	6969	7885	2.91 ± 0.20	0.51 ± 0.03	−2.40 (−2.78 to −2.02)	<0.001	3.16 ± 0.22	0.51 ± 0.03	−2.65 (−3.06 to −2.25)	<0.001
Hamburger	3729	4129	4.49 ± 0.17	0.68 ± 0.03	−3.81 (−4.15 to −3.47)	<0.001	4.86 ± 0.19	0.68 ± 0.02	−4.18 (−4.55 to −3.79)	<0.001
Sandwich	1947	2128	0.17 ± 0.01	0.25 ± 0.02	0.08 (0.04 to 0.12)	<0.001	0.22 ± 0.02	0.23 ± 0.02	0.01 (−0.04 to 0.07)	0.65
Fried chicken	750	999	3.14 ± 0.49	0.50 ± 0.12	−2.65 (−3.82 to −1.48)	<0.001	3.25 ± 0.50	0.50 ± 0.12	−2.74 (−3.95 to −1.54)	<0.001
Pizza	301	307	0.40 ± 0.20	0.13 ± 0.06	−0.28 (−0.60 to 0.04)	0.097	0.29 ± 0.14	0.14 ± 0.06	−0.16 (−0.35 to 0.04)	0.110
Mexican food	242	322	3.05 ± 0.15	0.41 ± 0.02	−2.65 (−2.93 to −2.37)	<0.001	3.95 ± 0.11	0.49 ± 0.04	−3.46 (−3.68 to −3.24)	<0.001

Table 2. **Change in Saturated Fat Content in Lunchtime Purchases at New York City Fast-Food Chains**

Chain Type	2007		2009		Change (95% CI), *g*	*P* Value
	Receipts, *n*	Mean Saturated Fat Content (±SE), *g*	Receipts, *n*	Mean Saturated Fat Content (±SE), *g*		
All receipts	6969	10.87 ± 0.28	7885	11.41 ± 0.28	0.55 (0.13 to 0.96)	0.011
Hamburger	3729	11.38 ± 0.24	4129	10.99 ± 0.27	−0.39 (−0.89 to 0.16)	0.132
Sandwich	1947	8.40 ± 0.21	2128	10.35 ± 0.26	1.95 (1.46 to 2.45)	<0.001
Fried chicken	750	14.12 ± 1.35	999	16.06 ± 1.02	1.94 (0.56 to 3.32)	0.006
Pizza	301	11.28 ± 2.08	307	9.58 ± 1.76	−1.69 (−3.80 to 0.49)	0.118
Mexican food	242	12.23 ± 0.79	322	11.20 ± 0.25	−1.03 (−2.27 to 0.21)	0.106

chicken chains. Trans fat content per 1000 kcal also decreased across the sample by 2.7 g per 1000 kcal (CI, −3.1 to −2.3 g per 1000 kcal [$P < 0.001$]). However, at sandwich chains, trans fat content per purchase increased by 0.1 g (0.2 vs. 0.3 g; CI, 0.0 to 0.1 g [$P < 0.001$]), whereas trans fat content per 1000 kcal, already low in 2007, remained constant.

Overall mean saturated fat content per purchase increased by 0.6 g (CI, 0.1 to 1.0 g [$P = 0.011$]) (**Table 2**), whereas mean trans plus saturated fat decreased by 1.9 g (13.8 vs. 11.9 g; CI, −2.5 to −1.2 g [$P < 0.001$]) (**Table 3**). Mean saturated fat increased by 2.0 g at sandwich chains (CI, 1.5 to 2.5 g [$P < 0.001$]) and by 1.9 g at fried chicken chains (CI, 0.6 to 3.3 g [$P = 0.006$]). Mean trans plus saturated fat decreased at 2 chain types and increased in 1. The reduction was greatest in hamburger chains (4.2 g; CI, −4.9 to −3.5 g [$P < 0.001$]) and Mexican food chains (3.7 g; CI, −5.2 to −2.2 g [$P < 0.001$]). Sandwich chains showed an increase of 2.0 g (8.6 vs. 10.6; CI, 1.5 to 2.6 g [$P < 0.001$]).

In our linear regression analysis, we excluded 231 additional purchases because of missing sex data. When controlling for total calories purchased, restaurant chain, customer sex, and restaurant location, poverty rate did not have a statistically significant influence on the change in trans fat content per purchase. The adjusted mean trans fat content decreased by 2.3 g per purchase from 2007 to 2009 (CI, −2.8 to −2.1 g [$P < 0.001$]), similar to our unadjusted findings (**Table 1**). In this model, there was a statistically significant but small association between calories and trans fat content (an additional 0.0024 g of trans fat per additional calorie; CI, 0.0021 to 0.0027 g [$P < 0.001$]). We saw no association between trans fat content of purchases and customer sex or neighborhood poverty level.

The maximum trans fat content of a single purchase decreased from 28 g in 2007 to 5 g in 2009, substantially reducing the skewing of the trans fat content distribution in 2009 (**Figure**). The maximum trans plus saturated fat content in a single purchase decreased from 96 g in 2007 to 60 g in 2009. The percentage of purchases with trans fat content listed as zero grams increased from 32% in 2007 to 59% in 2009.

DISCUSSION

Our study of a sample of NYC chain restaurant customers before and after implementation of the NYC regulation restricting restaurant trans fat use demonstrated an associated large and probably clinically meaningful reduction in the trans fat content of lunchtime purchases. The absolute decrease in trans fat per purchase amounted to 2.4 g. This reduction, which is equivalent to a 21.6-kcal decrease in trans fat per purchase (1 g trans fat = 9 kcal), is expected to affect the cardiovascular health of regular restaurant patrons; an increase of only 40 kcal of energy per day from trans fat for a person consuming a 2000-kcal/d diet has been estimated to increase the risk for coronary heart disease by 23% (1). Given that one third of calories in the United States comes from foods prepared away from

Table 3. **Change in Trans Plus Saturated Fat Content in Lunchtime Purchases at New York City Fast-Food Chains**

Chain Type	2007		2009		Change (95% CI), *g*	*P* Value
	Receipts, *n*	Mean Trans Plus Saturated Fat Content (±SE), *g*	Receipts, *n*	Mean Trans Plus Saturated Fat Content (±SE), *g*		
All receipts	6969	13.78 ± 0.40	7885	11.92 ± 0.30	−1.86 (−2.52 to −1.19)	<0.001
Hamburger	3729	15.87 ± 0.35	4129	11.67 ± 0.29	−4.20 (−4.92 to −3.49)	<0.001
Sandwich	1947	8.57 ± 0.21	2128	10.61 ± 0.27	2.03 (1.51 to 2.55)	<0.001
Fried chicken	750	17.27 ± 0.89	999	16.56 ± 1.14	−0.71 (−1.95 to 0.54)	0.27
Pizza	301	11.68 ± 2.25	307	9.71 ± 1.81	−1.97 (−4.27 to 0.34)	0.100
Mexican food	242	15.28 ± 0.93	322	11.61 ± 0.26	−3.67 (−5.17 to −2.17)	<0.001

home, this suggests a remarkable achievement in potential cardiovascular risk reduction through food policy.

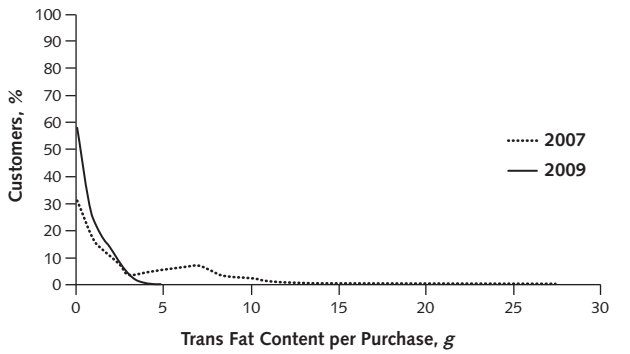
Our findings have implications beyond NYC. In the United States, as the NYC regulation was being implemented, some national chains that had locations in NYC announced related reformulations nationwide (17). Our results, therefore, suggest the potential for broader effect of local food policy on a country's food companies.

Some key reasons for the observed changes in trans fat content per purchase may include customers selecting a different mix of products, reformulated menu items, and items that have changed in size. Inspection of the most commonly purchased food items in chain types with the largest reductions in trans fat per purchase (hamburger, Mexican food, and fried chicken chains) revealed multiple examples of reformulation and new product introductions. For example, in fried chicken chains, the 2 most purchased types of food, fried chicken pieces and biscuits, had averages of 1 g and 1.75 g less trans fat, respectively, in 2009 than in 2007. In 2009, KFC introduced new grilled chicken menu items, all of which were listed as having zero grams of trans fat. In our data set, grilled chicken items became the fourth most commonly purchased type of food at fried chicken chains. As demonstrated, adjustment for calories in our regression analysis did not change the estimated difference in trans fat purchased per customer between the 2 years, and the change in trans fat per 1000 kcal remained substantial, suggesting that smaller portion sizes are not driving the reduction in trans fat content per purchase.

The concern that potential health advantages from reductions in trans fat would be offset by replacing it with saturated fat was also not substantiated by our study. Although we observed a slight overall increase in saturated fat content per purchase, trans fat and trans plus saturated fat decreased, indicating a net health benefit. In sandwich chains, a statistically significant increase in trans plus saturated fat was observed; however, the increase in trans fat was small and probably clinically insignificant. Furthermore, the increase in saturated and trans fat may well be the result of a documented increase in calories per purchase associated with increased portion size rather than reformulated menu items (16). Studies that looked at product reformulation alone found lower or unchanged levels of saturated fat when trans fat was reduced (13, 14).

Health disparities driven by socioeconomic determinants are one of the greatest challenges to advancing population health. Low-income NYC neighborhoods have death rates from heart disease that are 1.2 times those of high-income neighborhoods (18). To consider potential differences in trans fat exposure in restaurant chains based on neighborhood income, we assessed the change in trans fat content per purchase, controlling for neighborhood poverty rate of the store location. We found no statistically significant differences, suggesting that the use of a regulatory strategy provided equal benefit to patrons of restaurants in high- and low-poverty neighborhoods.

Figure. **Distribution of trans fat content per purchase.**



Trans fat content may be underestimated because companies can report trans fat values less than 0.5 g as zero grams of trans fat. In 2007, only 32% of customer purchases had zero grams of trans fat vs. 59% of customer purchases in 2009. Similarly, the maximum amount of trans fat in an individual purchase was 28 g in 2007 vs. 5 g in 2009.

Although our findings indicate an important policy success, they also identify areas that warrant further consideration. In 2009, 59% of purchases contained zero grams of total trans fat, an 86% increase from 2007. Yet, 40% of purchases still contained at least 0.5 g of trans fat (**Figure**) in 2009, although the mean content per purchase was lower than in 2007. A proportion of this trans fat is expected to be from naturally occurring sources; the NYC regulation made accommodation for these types of sources to avoid restricting milk and meat products. Under federal requirements, a product labeled as containing zero grams of trans fat may still contain trans fat from natural or industrial sources, as long as it contains less than 0.5 g per serving (13). For feasibility and enforcement purposes, the trans fat regulations in NYC and many other localities relied on the zero-gram criterion to exclude products from use; however, this approach may not fully eliminate industrial sources.

Our study design has both limitations and strengths. Data were collected from patrons of fast-food chains only and are therefore not representative of all fast-food restaurants. Nonchain restaurants are generally not covered by existing regulations requiring public disclosure of nutritional information. As a result, it was not feasible to include them in our survey sample. The fast-food chains included in the study are national chains that have publicly available nutritional information, subjecting their menu items to increased public scrutiny. Therefore, it is possible that the magnitude of the reduction in trans fat content associated with the NYC trans fat regulation may differ in nonchain restaurants that were also covered by the regulation. Finally, our study design is cross-sectional, and we can therefore assess only the association of observed changes with the regulation's implementation—causation

cannot be decisively attributed. Study strengths include analysis of reported nutritional value of purchases instead of menu offerings, allowing us to consider the combined influences of product availability and consumer choice. Furthermore, the number of receipts collected was large (more than 14 000), and the timing of collection was proximate to regulation (within 3 months before phase-in started and within 1 year after phase-in was complete).

Our study suggests that reductions in the trans fat content of restaurant purchases can be achieved without an offsetting increase in saturated fat through regulation of the restaurant food environment. It also provides objective findings that warrant further investigation and consideration for federal action and illustrates the importance of ongoing research and evaluation of nutritional policy. The marketplace has changed substantially in recent years, demonstrating that reformulation to remove trans fat is feasible in both restaurant and packaged foods. Local regulation seems to be successful at reducing exposure to trans fat in restaurants. However, full elimination of exposure to the industrially produced form of this harmful and unnecessary addition to our food supply, found in partially hydrogenated oils, will require federal action.

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Note: All authors were employed by the New York City Department of Health and Mental Hygiene at the time that this analysis was conducted. For contact purposes only, Dr. Angell is currently employed by the Centers for Disease Control and Prevention.

Disclaimer: All authors had full access to the data and can take responsibility for the integrity of the data and the accuracy of the data analysis.

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