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Assessment of Calories Purchased After Calorie Labeling of Prepared Foods in a Large Supermarket Chain

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IMPORTANCE Calorie labels for prepared (ie, ready-to-eat) foods are required in large chain food establishments in the US. Large evaluations in restaurants suggest small declines in purchases of prepared foods after labeling, but to the authors' knowledge, no studies have examined how this policy influences supermarket purchases.

OBJECTIVE To estimate changes in calories purchased from prepared foods and potential packaged substitutes compared with control foods after calorie labeling of prepared foods in supermarkets.

DESIGN, SETTING, AND PARTICIPANTS This controlled interrupted time series compared sales 2 years before labeling implementation (April 2015-April 2017) with sales 7 months after labeling implementation (May 2017-December 2017). Data from 173 supermarkets from a supermarket chain with locations in Maine, Massachusetts, New Hampshire, New York, and Vermont were analyzed from March 2020 to May 2022.

INTERVENTION Implementation of calorie labeling of prepared foods in April 2017.

MAIN OUTCOMES AND MEASURES Purchased items were classified as prepared foods, potential packaged substitutes for prepared foods, or all other (ie, control) foods. The primary outcome was mean weekly calories per transaction purchased from prepared foods, and the secondary outcome was mean weekly calories per transaction purchased from similar packaged items (for substitution analyses). Analyses of prepared and packaged foods were stratified by food category (bakery, entrées and sides, or deli meats and cheeses).

RESULTS Among the included 173 supermarkets, calorie labeling was associated with a mean 5.1% decrease (95% CI, −5.8% to −4.4%) in calories per transaction purchased from prepared bakery items and an 11.0% decrease (95% CI, −11.9% to −10.1%) from prepared deli items, adjusted for changes in control foods; no changes were observed for prepared entrées and sides (change = 0.3%; 95% CI, −2.5% to 3.0%). Labeling was also associated with decreased calories per transaction purchased from packaged bakery items (change = −3.9%; 95% CI, −4.3% to −3.6%), packaged entrées and sides (change = −1.2%; 95% CI, −1.4% to −0.9%), and packaged deli items (change = −2.1%; 95% CI, −2.4% to −1.7%).

CONCLUSIONS AND RELEVANCE In this longitudinal study of supermarkets, calorie labeling of prepared foods was associated with small to moderate decreases in calories purchased from prepared bakery and deli items without evidence of substitution to similar packaged foods.

Invited Commentary

Supplemental content

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Nutrition labeling policies aim to promote customer awareness of the healthfulness of foods in retail establishments. Calorie labeling of prepared (ready-to-eat) foods is required in all US food retailers with at least 20 locations, as directed by a provision of the Affordable Care Act.[1] This policy, implemented nationwide in May 2018 and earlier in some chains, was intended to provide customers with information at the point of sale to encourage healthier choices. In restaurant settings, several small studies of voluntary labeling initiatives and local labeling laws (ie, before nationwide implementation) found no association of labeling with calories purchased.[2-7] However, some large-scale evaluations[8-10] and 1 randomized trial[11] detected 3% to 6% declines in calories purchased after labeling.

No study, to our knowledge, has examined associations of calorie labeling with supermarket purchases. This is a substantial gap considering that more than 90% of supermarkets sell prepared foods,[12] such as fresh bakery items (eg, muffins, donuts), ready-to-eat entrées (eg, premade sandwiches), and deli meats and cheeses.[13] In 2016, grocery stores sold nearly $30 billion in prepared foods[14]; current sales are likely much higher given retailers' rapid expansion of prepared food offerings.[15] This growth has potential adverse consequences because prepared meals tend to be less healthy than homemade meals (eg, higher in calories, saturated fat, and sodium) and are often served in larger portions, encouraging overconsumption.[16-18] Customers also underestimate prepared foods' calorie content[2,19]; greater transparency via labeling could improve customer choices.

To address this gap, we examined associations of labeling with calories purchased across a large supermarket chain. We investigated changes in calories purchased from prepared foods and possible packaged substitutes compared with all other foods in controlled interrupted time series (ITS) analyses.

Key Points

Question Was calorie labeling of prepared foods in supermarkets associated with changes in calories purchased from prepared foods and potential packaged substitutes?

Findings In this longitudinal study of 173 supermarkets followed from 2015 to 2017, calories purchased from prepared bakery items declined by 5.1% after labeling, and calories purchased from prepared deli items declined by 11.0% after labeling, adjusted for prelabeling trends and changes in control foods; no changes were observed among prepared entrées and sides. Calories purchased from similar packaged items did not increase after labeling.

Meaning Calorie labeling of prepared supermarket foods was associated with overall small declines in calorie content of prepared foods without substitution to similar packaged foods.

Methods

In this longitudinal study, we used a quasi-experimental design to examine changes in calories purchased from prepared foods from a supermarket chain before calorie labeling (April 2015-April 2017) and after calorie labeling (May 2017-December 2017). We compared these changes with control foods, which we hypothesized would not be affected by calorie labeling but would respond similarly to regional demand shocks (eg, acute weather events) as prepared foods. We also examined postlabeling changes in calories purchased from packaged foods that could be potential substitutes for prepared foods. This study was approved by the Harvard Pilgrim Health Care Institutional Review Board. We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Study Sample

We obtained transaction-level sales data on all purchases from April 1, 2015, to December 31, 2017, for 194 supermarkets in a regional chain in rural, suburban, and urban areas of Maine, Massachusetts, New Hampshire, New York, and Vermont. Calorie labeling of prepared foods was implemented the week of April 24, 2017, across all locations, approximately 1 year before the federal enforcement date.[20] We analyzed sales from 173 supermarkets that were continuously open over the study period. We aggregated sales at the store-week level to reflect the fact that, on average, people in the US go grocery shopping every 7 days[21] and to reduce extraneous variation in purchases due to day-to-day fluctuations. The analytic sample covered sales from April 6, 2015, to December 31, 2017, and included 24 739 store-week observations. The data were analyzed from March 2020 to May 2022.

Data

There were 4 459 407 189 items purchased across all stores over the study period. We excluded 689 277 683 nonfood items (15.5% of purchased items) and an additional 335 574 091 items that were missing a product description and could not be identified (7.5%), yielding an analytic sample of 3 434 555 415 items purchased across 374 416 423 transactions.

The data included each item's Universal Product Code, product description, date of purchase, price, quantity purchased, and store ID. The data identified online transactions and transactions that were at least partially paid for using Supplemental Nutrition Assistance Program (SNAP) benefits.

We obtained nutrition and labeling data from Guiding Stars,[22] a food labeling program that compiles nutrition information for items sold in supermarkets[23] and that oversaw implementation of labeling at the chain (see eMethods in the Supplement for photos of labeled prepared foods). Guiding Stars provided products' labeling status and updated nutrition information every 6 months, including product reformulations and newly added or discontinued products. To verify labeling status, we conducted an extensive data review process using the Guiding Stars data set, product websites, and guidance from Guiding Stars personnel (see Grummon et al[13]). We linked the sales data and Guiding Stars labeling and nutrition data on Universal Product Code and time.

Measures

We calculated total calories purchased from each item by multiplying calories per serving by servings per container. This

yielded complete data for 79.0% of sold items. We completed various procedures to fill in the missing calorie data (see eMethods in the Supplement) to avoid detecting changes in calories purchased that were due to missing data on items' calorie content.

We analyzed 3 categories of prepared foods (bakery, entrées and sides, and deli meats and cheeses), which we classified using Guiding Stars food categories and a previously developed food grouping system[13,24] (eTable 1 in the Supplement provides definitions and examples). Our analyses covered approximately 72% of prepared food sales. We excluded prepared produce (eg, sliced fruit), condiments and sauces (eg, side of olive oil at salad bar), and whole seafood (eg, whole steamed lobster) because customers would be highly unlikely to respond to labeling in these categories; these categories comprised approximately 23% of prepared food sales. We further excluded prepared entrées and sides from the supermarket hot bar (approximately 5% of prepared food sales) because sales were recorded solely as "hot bar" items without information on specific products selected.

We additionally identified packaged foods in each category (bakery, entrées and sides, and deli) that were not subject to the new labeling requirement and could be substitutes for prepared foods (eg, packaged cookies, frozen dinners, prepackaged deli meats). These items displayed calorie content on a Nutrition Facts label (NFL).

We classified all other foods (ie, all foods excluding prepared foods and packaged substitutes) as control foods. These control foods included a broad array of items, including produce, meats, milk, and others. Although these foods could have different sales trends than prepared foods, including them could adjust for time-varying confounding caused by acute shocks (eg, weather) or long-term trends affecting entire stores (eg, stores gaining overall popularity).

The primary outcome was mean weekly calories per transaction purchased from prepared foods. This was calculated by dividing total calories purchased from prepared foods by the total number of transactions in that store and week. We used a similar approach to calculate mean weekly calories per transaction purchased from potential packaged substitutes (secondary outcome) and control foods. We additionally calculated mean weekly prepared food items per transaction and calories per item purchased from prepared foods to explore potential mechanisms through which customers changed prepared calorie purchases after labeling (ie, changes in quantity vs type of foods purchased).

We calculated the percentage of transactions purchased with SNAP benefits and the percentage of transactions made online each week. We obtained 2015-2019 American Community Survey data[25] to evaluate the demographic composition of supermarkets' census tracts (eg, race, ethnicity, education, percentage of households with incomes below the poverty level).

Statistical Analysis

We fit controlled ITS models to estimate associations of labeling with purchases.[26,27] These models project what purchases would have been in the postintervention period had preintervention trends continued and adjust that projection by differencing out pre-post changes in the control foods.[27] This approach is similar to difference-in-differences analysis, with the additional benefit of adjusting for preintervention trends.[27-29]

We implemented ITS using generalized linear mixed models with random intercepts for stores and a log link and gamma distribution to estimate percentage changes. We excluded data from the week of implementation and the 2 weeks before and after to account for potential variation in implementation rollout. Observations were weighted by stores' total prelabeling transactions so that estimates accounted for between-store differences in sales volume. The model included variables for week (continuous), group (0 = control foods, 1 = prepared foods and packaged substitutes), pre-post period (0 = pre, 1 = post), week × group,

Table 1. Descriptive Characteristics of Supermarkets Included in the Analytic Sample

Characteristic	Finding[a]
Location, No. (%)	
Maine	59 (34)
Massachusetts	16 (9)
New Hampshire	33 (19)
New York	48 (28)
Vermont	17 (10)
Census tracts with supermarkets from the chain, %[b]	
Race	
American Indian or Alaska Native	0.3 (0.6)
Asian American or Pacific Islander	2.4 (2.9)
Black or African American	2.6 (4.3)
White	91.1 (7.8)
Other race or >1 race[c]	6.0 (4.8)
Ethnicity	
Hispanic or Latino	4.2 (4.9)
Not Hispanic or Latino	95.8 (4.9)
Household income, $	
<25 000	18.5 (9.7)
25 000-49 999	20.2 (5.7)
50 000-74 999	18.1 (4.9)
75 000-99 999	14.0 (4.1)
≥100 000	29.2 (13.6)
Education (among adults aged ≥25 y)	
Less than high school diploma	7.5 (4.3)
High school diploma or some college	57.6 (11.3)
Bachelor's degree or higher	34.8 (13.8)
Received SNAP in past 12 mo	11.4 (8.2)
Transactions	
Weekly No. of transactions	14 141 (4132)
Transactions using SNAP benefits, %[d]	3.9 (3.0)
Online transactions, %	0.2 (0.5)
Prepared items/transaction	0.5 (0.1)
Prepared calories/item	771 (61)

Abbreviation: SNAP, Supplemental Nutrition Assistance Program.

[a] Unless otherwise indicated, all data are reported as mean (SD) values.

[b] Using data from the 2015-2019 American Community Survey.

[c] Some other race alone or 2 or more races (including or excluding some other race).

[d] Includes all transactions where SNAP benefits were used to pay for any part of the purchase.

Table 2. Changes in Weekly Mean Calories per Transaction of Prepared Foods and Possible Packaged Substitutes After Calorie Labeling From Controlled ITS Models[a]

		Postlabeling		
	Prelabeling, observed mean (95% CI)[b]	Observed mean (95% CI)[c]	Counterfactual mean (95% CI)[d]	% Difference, observed−counterfactual (95% CI)[e]
Prepared foods				
Prepared bakery items	172.2 (167.5 to 176.9)	180.8 (175.8 to 185.9)	190.6 (185.2 to 196.0)	−5.1 (−5.8 to −4.4)
Prepared entrées and sides[f]	86.3 (83.6 to 89.0)	90.9 (88.3 to 93.5)	90.7 (86.7 to 94.8)	0.3 (−2.5 to 3.0)
Prepared deli items	162.3 (156.7 to 168.0)	145.8 (140.7 to 150.9)	163.0 (157.0 to 169.0)	−11.0 (−11.9 to −10.1)
Packaged substitutes				
Packaged bakery items	447.0 (435.4 to 458.7)	437.5 (426.2 to 448.7)	456.7 (444.8 to 468.5)	−3.9 (−4.3 to −3.6)
Packaged entrées and sides	612.8 (597.5 to 628.1)	600.7 (585.9 to 615.6)	608.3 (593.2 to 623.5)	−1.2 (−1.4 to −0.9)
Packaged deli items	471.8 (458.7 to 485.0)	490.9 (477.2 to 504.6)	501.3 (487.1 to 515.5)	−2.1 (−2.4 to −1.7)

Abbreviation: ITS, interrupted time series.

[a] All models accounted for postlabeling changes in the control series (all foods except packaged and prepared foods) and were adjusted for holidays (weeks of Thanksgiving to Christmas, week of Easter, and week of Fourth of July), sine and cosine Fourier terms, the percentage of transactions purchased with Supplemental Nutrition Assistance Program benefits, and the percentage of transactions made online. Model parameters are available in eTable 2 in the Supplement.

[b] Mean calories per transaction over each week of the prelabeling period calculated from model parameters.

[c] Mean calories per transaction over each week of the postlabeling period calculated from model parameters.

[d] Mean calories per transaction over each week of the postlabeling period assuming labeling not occurred. This was calculated from model parameters omitting level and trend changes for the food group of interest (ie, assuming that prepared foods/packaged substitutes experienced the exact same postlabeling changes as the control series).

[e] Mean percentage difference in calories per transaction in the postlabeling period compared with the estimated counterfactual.

[f] Excludes hot bar items due to lack of available calorie information.

week × period, group × period, week × group × period, and covariates for seasonality,[30] holidays (weeks of Thanksgiving, Christmas, Easter, and Fourth of July), and the percentage of transactions made online and with SNAP benefits (eMethods in the Supplement provide model details and coefficient interpretation). Interaction terms for group × period and week × group × period allowed us to estimate postlabeling changes in the level and trend, respectively, for prepared foods vs control foods.

We calculated the observed mean calories per transaction purchased from prepared foods in the prelabeling and postlabeling periods using model parameters. We also calculated the estimated counterfactual calories per transaction purchased from prepared foods (ie, assuming the same pre-post change as control foods but no changes beyond that). We calculated the difference between the observed and counterfactual outcomes for each week and averaged across all weeks in the postlabeling period to calculate mean percentage changes in outcomes postlabeling.

We conducted several sensitivity analyses. These included estimating models that used only 1 year of prelabeling data in case this represented the true baseline trend; removing 4 weeks before and after labeling to allow for a longer rollout period; including only the same months each year (May to December) to reduce potential residual confounding by seasonality; removing purchases made with SNAP benefits because SNAP cannot be used to purchase prepared foods[31]; removing online purchases because calorie labels might have been viewed differently online vs in store; classifying freshly baked breads as prepared bakery items because the chain added calorie labels to breads (despite bread not being in scope for labeling); restricting analyses to items offered every week of the study to preclude results being due to addition or discontinuation of prepared foods; and using an uncontrolled ITS model for all outcomes, in case this better estimated the counterfactual than the control foods.

In stratified analyses, we estimated associations by quartile of percent poverty of supermarkets' census tracts. This was motivated by previous studies documenting lower nutrition label use in populations with lower socioeconomic status.[32-34]

A significance level of $P = .05$ was used for all statistical tests. We conducted analyses using Stata statistical software, release 16 (StataCorp LLC), and calculated 2-sided 95% CIs.

Results

A total of 173 supermarkets were included in the analysis. Stores had a mean (SD) of 14 141 (4132) weekly transactions in the prelabeling period (**Table 1**). Prelabeling transactions contained a mean (SD) of 0.5 (0.1) prepared items; prepared items contained a mean (SD) of 771 (61) calories.

In the prelabeling period, the average transaction contained 172.2 (95% CI, 167.5-176.9) calories from prepared bakery items. Had labeling not occurred, the estimated mean transaction in the postlabeling period would contain 190.6 (95% CI, 185.2-196.0) calories from prepared bakery items. However, after labeling, the mean transaction contained 180.8 (95% CI, 175.8-185.9) calories from prepared bakery items, a 5.1% decrease (95% CI, −5.8% to −4.4%) relative to counterfactual projections. For entrées and sides, the prelabeling mean was 86.3 (95% CI, 83.6-89.0) calories per transaction, and there was no change after labeling vs the counterfactual (change = 0.3%; 95% CI, −2.5% to 3.0%). For prepared deli items, the prelabeling mean was 162.3 (95% CI, 156.7-168.0) calories per transaction, and labeling was associated with an 11.0% decrease (95% CI, −11.9% to −10.1%) (**Table 2**; **Figure**). On the absolute scale, these re-

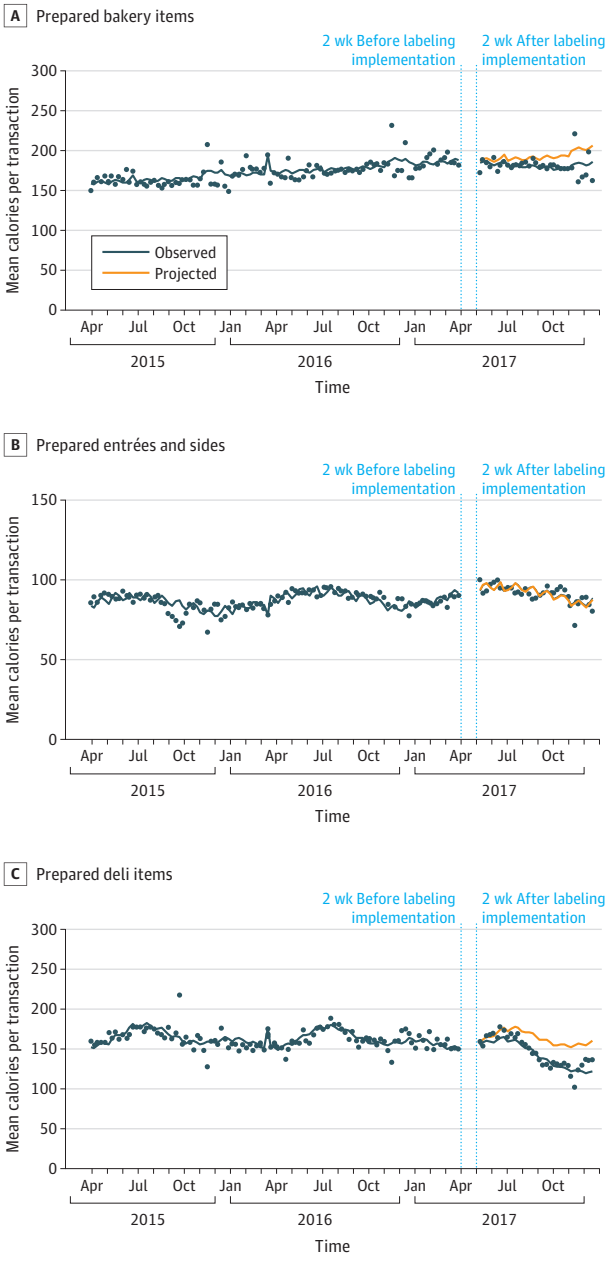
sults approximately translate to a 10-calorie-per-transaction decrease for prepared bakery items, no change for prepared entrées and sides, and an 18-calorie-per-transaction decrease for prepared deli items (eTable 2 in the Supplement provides model parameters and interpretations). Associations were generally similar across census tract poverty levels (**Table 3**).

Labeling was also associated with decreased calories purchased from packaged foods that were hypothesized as substitutes for prepared foods (Table 2). After labeling, calories per transaction declined for packaged bakery items (change = −3.9%; 95% CI, −4.3% to −3.6%), packaged entrées and sides (change = −1.2%; 95% CI, −1.4% to −0.9%), and packaged deli items (change = −2.1%; 95% CI, −2.4% to −1.7%).

Sensitivity analyses generally yielded similar results (eTable 3 in the Supplement), with a few exceptions. When assuming an 8-week rollout, the association was slightly attenuated for prepared bakery item calories (change = −3.2%; 95% CI, −4.0% to −2.5%). When using just 1 year of prelabeling data, results were slightly attenuated for prepared deli item calories (change = −8.7%; 95% CI, −9.8% to −7.6%) but demonstrated a positive association for prepared entrée and side calories (change = 6.8%; 95% CI, 4.7%-8.9%). When including only data from May to December of each year, calorie purchases of entrées and sides declined (change = −5.4%; 95% CI, −9.0% to −1.9%). When restricting to items continuously offered over the study period (eTable 4 in the Supplement), there was a slight reduction in calories per transaction from prepared entrées and sides (change = −2.8%; 95% CI, −3.9% to −1.7%) and an attenuated association for prepared deli items (change = −6.3%; 95% CI, −7.3% to −5.3%). Uncontrolled ITS models yielded very similar results for prepared and packaged foods (eTable 5 in the Supplement) and estimated a 0.4% decline (95% CI, −0.7% to −0.2%) for control foods after labeling.

After labeling, customers purchased fewer prepared bakery (change = −4.2%; 95% CI, −4.9% to −3.5%) and prepared deli items (change = −13.3%; −14.1% to −12.5%) per transaction (eTable 6 in the Supplement). Labeling was associated with slight increases in calories per item for prepared entrées and sides (change = 2.1%; 95% CI, 1.3%-2.8%) and deli items (change = 3.3%; 95% CI, 2.7%-3.9%).

Figure. Changes in Mean Calories per Transaction From Prepared Food Categories After Calorie Labeling Implementation



The graph shows the mean calories per transaction across all supermarkets (blue dots), the observed trends in calories per transaction (blue line), and the projected trend assuming labeling had not been implemented (ie, counterfactual; orange line). The 2 weeks before and after labeling implementation are indicated by the vertical dashed lines. The control group is not shown due to scale, but the depicted projected trends adjust for pre-post changes in the control group.

Discussion

This longitudinal study of 173 supermarkets in a large regional chain found that calorie labeling of prepared foods was associated with small to moderate decreases in calories purchased from prepared bakery and deli items, but not entrées and sides, 7 months after labeling implementation. The results were generally similar by socioeconomic status of supermarket neighborhoods. These decreases were not offset by increased purchases from similar packaged foods that were not subject to the labeling mandate.

Although we estimated small absolute decreases in calories purchased from prepared bakery (approximately 10 calories per transaction) and deli items (approximately 18 calories per transaction), these declines could be meaningful at the population level given the ubiquity of calorie labels in retail settings, the frequency with which people consume prepared foods,[16] and the growing market for supermarket prepared foods.[14,15] It is difficult to predict how these findings translate to changes in consumption or health because we did not have these data. However, simulation studies have suggested that small population-level changes in calorie consumption can pre-

Table 3. Changes in Weekly Mean Calories per Transaction of Prepared Foods After Calorie Labeling by Quartiles of Poverty Rates of Supermarkets' Census Tracts[a,b]

	Prelabeling, observed mean (95% CI)[c]	Postlabeling		
		Observed mean (95% CI)[d]	Counterfactual mean (95% CI)[e]	% Difference, observed−counterfactual (95% CI)[f]
Prepared bakery items				
Quartile 1	180.2 (167.5 to 193.0)	188.7 (176.6 to 200.8)	197.8 (184.1 to 211.5)	−4.6 (−6.2 to −3.0)
Quartile 2	168.9 (161.1 to 176.7)	174.8 (166.4 to 183.3)	186.5 (177.7 to 195.4)	−6.3 (−7.4 to −5.1)
Quartile 3	175.2 (165.6 to 184.9)	185.4 (174.6 to 196.2)	195.8 (184.4 to 207.3)	−5.3 (−7.0 to −3.7)
Quartile 4	167.4 (156.8 to 178.0)	176.3 (165.1 to 187.6)	184.5 (171.8 to 197.1)	−4.4 (−5.9 to −2.9)
Prepared entrées and sides[g]				
Quartile 1	84.0 (78.8 to 89.2)	89.4 (83.9 to 94.9)	90.6 (82.8 to 98.4)	−1.3 (−5.4 to 2.9)
Quartile 2	83.0 (79.6 to 86.4)	89.8 (85.0 to 94.7)	86.2 (82.2 to 90.1)	4.3 (0.8 to 7.8)
Quartile 3	91.3 (85.8 to 96.7)	94.6 (89.8 to 99.4)	97.0 (87.2 to 106.7)	−2.4 (−9.5 to 4.7)
Quartile 4	81.7 (76.6 to 86.7)	85.1 (80.0 to 90.2)	83.8 (78.2 to 89.3)	1.6 (−1.4 to 4.6)
Prepared deli items				
Quartile 1	179.8 (166.3 to 193.3)	159.1 (147.0 to 171.2)	182.1 (167.5 to 196.8)	−13.1 (−14.8 to −11.3)
Quartile 2	160.4 (148.6 to 172.2)	143.1 (132.1 to 154.0)	159.3 (146.6 to 172.1)	−10.7 (−12.3 to −9.1)
Quartile 3	159.2 (147.8 to 170.7)	142.4 (132.6 to 152.2)	157.8 (146.7 to 168.9)	−10.2 (−12.0 to −8.4)
Quartile 4	159.9 (148.8 to 171.0)	145.1 (135.2 to 154.9)	160.0 (148.8 to 171.3)	−9.8 (−11.7 to −8.0)

[a] All models accounted for postlabeling changes in the control series (all foods except packaged and prepared foods) and were adjusted for holidays (weeks of Thanksgiving to Christmas, week of Easter, and week of Fourth of July), sine and cosine Fourier terms, the percentage of transactions purchased with Supplemental Nutrition Assistance Program benefits, and the percentage of transactions made online.

[b] Quartile 1: <6.0%; quartile 2: ≥6.0% to <9.9%; quartile 3: ≥9.9% to <13.6%; quartile 4: ≥13.6% households with income below the federal poverty line.

[c] Mean calories per transaction over each week of the prelabeling period calculated from model parameters.

[d] Mean calories per transaction over each week of the postlabeling period calculated from model parameters.

[e] Mean calories per transaction over each week of the postlabeling period assuming labeling not occurred. This was calculated from model parameters omitting level and trend changes for the food group of interest (ie, assuming that prepared foods/packaged substitutes experienced the exact same postlabeling changes as the control series).

[f] Mean percentage difference in calories per transaction in the postlabeling period compared with the estimated counterfactual.

[g] Excludes hot bar items due to lack of available calorie information.

vent thousands of cases of obesity.[35] Moreover, because prepared bakery and deli items are among the top contributors to added sugar[36] and sodium[37] in the US diet, these results also suggested potential cardiometabolic benefits, especially for consumers who respond strongly to the labels. However, given the small overall reductions, the present results suggest that for broader influence on population-level diet, calorie labeling should be implemented alongside other evidence-based nutrition interventions, such as sweetened beverage taxes[38-40] and improved school nutrition standards.[41,42]

To our knowledge, this is the first study to estimate associations of calorie labeling with prepared food purchases in supermarkets. A previous study on perceptions of supermarket calorie labeling among 393 shoppers found that 16% reported that they noticed labels and that labeling was not associated with food choices.[43] Associations of calorie labeling with restaurant purchases have been mixed,[2-11] with larger quasi-experimental studies and 1 randomized trial finding 3% to 6% declines in calorie purchases.[8-11] Reductions in prepared food purchases in the present study were consistent with these prior studies, though reductions for prepared deli items were larger.

The exploratory analyses suggest that the declines in calories per transaction from prepared bakery and deli items may have been explained by customers purchasing fewer prepared items, rather than switching to lower-calorie items, a pattern also observed in restaurants.[8-10] Our previous study of prepared food offerings in the same chain suggested reformulation of continuously offered items is unlikely to explain the present results.[13] We also explored whether the main associations we observed may have been explained by changes in prepared offerings over time by restricting analyses to prepared foods continuously available throughout the study. Those analyses revealed very similar results as the main analysis for prepared bakery items, a lesser decrease for prepared deli items, and a slight decrease for prepared entrées and sides (vs no change in the main analysis). The main association for prepared deli items, therefore, may have been partially explained by changes in prepared offerings; any small decrease for prepared entrées and sides may have been obscured by this same issue. We were not able to discern from the data whether changes in offerings confounded the associations or were mechanisms of change (ie, if some items were discontinued due to labeling). Still, results from these analyses supported the overall findings of small to moderate postlabeling decreases in calories purchased from prepared foods.

The reduction in calories purchased from potential packaged food substitutes was unexpected. One possible explanation could be spillover effects (ie, labeling may have alerted customers to the high calorie content of similar packaged foods, reducing demand). Spillover effects have been observed in other studies of nutrition labeling programs[44-46] and food marketing.[47] This result also could have been explained by changes to the NFL for packaged foods, which was updated in 2016 to emphasize calories and include new information on some nutrients (eg, added sugars).[48] Manufacturers were not

required to implement the new NFL before 2020, though some did as early as 2017,[49] around the same time as calorie labeling. Customers may have reduced purchases of some packaged foods in response to the new NFL, especially because many were high in added sugars.[50] It is also possible that customer interest in these food categories decreased over time, which could partially explain the decreases for both prepared and packaged items. Given this uncertainty, future investigation of the associations of prepared food calorie labels with packaged foods is warranted.

We observed generally similar associations by poverty level of supermarket neighborhoods. This finding is important given concerns that labeling could exacerbate nutritional disparities by yielding the largest benefits among those with higher socioeconomic status and greater health literacy.[32-34] Some previous studies of restaurant calorie labeling have identified disparate associations by socioeconomic indicators[9,10] but, like the present study, were limited by having only neighborhood-level socioeconomic measures.

Limitations

This study had limitations. First, we did not have a control group because all stores implemented calorie labeling at the same time, but we used preintervention trends in prepared food purchases and a series of control foods to estimate counterfactual outcomes. However, the lack of control supermarkets meant that temporal changes unrelated to labeling and not captured by pre-post changes in control food sales could still have biased the outcomes. The reduction in sales for packaged and control items could indicate that there was some larger influence on overall sales that could explain some but not all of the findings for prepared foods. Second, there may have been errors in nutrition or labeling information in the Guiding Stars data set, though we conducted an extensive review process to correct errors and fill in missing data[13] and do not expect any remaining errors to differ by intervention period. Third, the results for prepared entrées and sides were not as robust to sensitivity analyses as the other categories, particularly for analyses that included different time periods. This could be because the analyses did not include hot bar items. If customers substituted between hot bar items and other entrées and sides differently over time (eg, in response to additions and/or discontinuations of hot bar offerings), this could explain the results' sensitivity to including different time periods. Lastly, the supermarkets were located in neighborhoods with a greater proportion of White and non-Hispanic/Latino residents than the overall US population,[51] potentially limiting generalizability. However, supermarket neighborhoods had similar income and education distributions as the overall US population.

Conclusions

Findings from this longitudinal study indicate that calorie labeling in a supermarket chain was associated with small to moderate decreases in calories purchased from prepared bakery and deli items 7 months after labeling implementation. These declines may lead to population-level health benefits if they translate to similar changes in consumption.

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