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Calorie Labeling and Product Reformulation: A Longitudinal Analysis of Supermarket Prepared Foods

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Abstract

Introduction: The 2010 Affordable Care Act required chain retail food establishments, including supermarkets, to post calorie information for ready-to-eat “prepared” foods. Implementation of calorie labeling could spur companies to reduce calorie content of prepared foods, but few studies have explored this. This study evaluates changes in calorie content of prepared foods at 2 large U.S. supermarket chains after they implemented calorie labels in April 2017.

Methods: The chains (≈1,200 stores) provided data on the calorie content and labeling status of all items sold between July 2015 and January 2019. In 2021, analyses used a difference-in-

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differences approach to examine changes in calorie content of prepared bakery, entree, and deli items from pre- to post-labeling compared with changes in similar foods not subject to the new labeling requirement. Primary analyses examined continuously available items; exploratory analyses examined items newly introduced to the marketplace.

Results: Relative to changes in comparison foods not subject to the labeling requirement, continuously available prepared bakery items decreased by 7.7 calories/item after calorie labels were implemented (95% CI= -12.9, -2.5, $p=0.004$, $\approx 0.5\%$ reduction). In exploratory analyses, prepared bakery items introduced after calorie labeling contained 440 fewer calories/item compared with those introduced before calorie labeling (95% CI= -773.9, -106.1, $p=0.01$, $\approx 27\%$ reduction), driven by reductions in product size. No changes were observed in calorie content of continuously available or newly introduced prepared entrees or deli items.

Conclusions: Implementing calorie labels could encourage product reformulation among some types of prepared supermarket foods. These supply-side changes could lead to reductions in caloric intake.

INTRODUCTION

Unhealthy diet is a leading cause of death in the U.S.¹ Consumption of ready-to-eat foods prepared away from home (“prepared foods”) is a key factor contributing to unhealthy diets and diet-related diseases, including obesity.²⁻⁴ Approximately one third of Americans’ total daily calories come from prepared foods.² Compared with foods made at home, prepared foods are higher in saturated fat, cholesterol, and sodium^{5,6}; lower in fiber, iron, and calcium^{5,6}; and served in larger portions, contributing to excess calorie consumption⁷⁻⁹ and obesity.^{2,4,10}

To encourage consumers to select lower-calorie foods and spur food retailers to offer lower-calorie options, the 2010 Affordable Care Act¹¹ required chain food retailers to post calorie information on prepared foods (implemented nationally in May 2018).^{12,13} Although Americans have traditionally purchased prepared foods from restaurants, 90% of supermarkets now sell prepared foods.¹⁴ Americans buy >\$30 billion in prepared foods from supermarkets each year,¹⁵ and sales of prepared foods are increasing more rapidly in supermarkets¹⁶ than in restaurants.¹⁷ Yet, little is known about prepared foods sold in supermarkets, including the potential effect of calorie labeling.

To date, no studies have examined whether calorie labeling could spur product reformulation among supermarket prepared foods. Although a growing body of research has examined how consumers respond to menu calorie labels,¹⁸⁻²⁵ research on industry response is much more limited. Some studies have examined changes in calorie content of prepared foods sold before and after labeling implementation,^{18,26-28} but these studies focused on restaurants, not supermarkets. Other studies have examined supermarket foods, but have focused on other labeling policies, such as trans fat labeling²⁹ and nutrient warning labels.³⁰

This study assesses changes in the calorie content of prepared foods sold at 2 large supermarket chains after implementation of calorie labels. Consumers may respond differently to calorie labels depending on the type of product on which they appear.^{25,31-34}

These reactions could prompt differential reformulation across product categories. Thus, this study examines changes in calorie content separately for bakery items, entrees and sides, and deli meats and cheeses, products that are commonly purchased at supermarkets³⁵ and for which calorie labels could elicit different consumer reactions.^{25,31–34} Companies can reduce products' calorie content via 2 mechanisms: making the product less calorie dense (e.g., by replacing sugar with a lower-calorie sweetener) and making the product smaller. Thus, this study also examines energy density and product size to provide insight on the mechanisms of reformulation.

METHODS

Study Sample

This study was conducted in 2 large supermarket chains comprising $\approx 1,200$ stores located throughout the Northeast, Mid-Atlantic, and Southeast regions of the U.S. Counties with stores from 1 or both chains were similar to the average U.S. county in age, sex, race, ethnicity, education, and income distributions (Appendix Table 1). Both chains are traditional supermarkets (i.e., not specialty stores or discounters) and serve rural, suburban, and urban areas across neighborhoods with varied income levels. Both chains participate in Guiding Stars, a widely used shelf tag food labeling program³⁶ that uses an algorithm to evaluate and communicate the nutritional quality of foods.³⁷ Additionally, both chains implemented calorie labeling in April 2017 in anticipation of the federal mandate.¹¹ The mandate was originally slated for implementation in 2015 but was delayed successively. The last delay came in May 2017 just 1 day before the planned enforcement date, leading to a final implementation date of May 2018.³⁸ The last-minute delay meant that the chains in this study implemented labels as planned in 2017.

Measures

The Guiding Stars program provided nutrition information on foods sold at any store in the 2 chains. In total, Guiding Stars provided 8 repeated cross-sections of data, separated by 6-month intervals ("timepoints"), with 4 timepoints before the chains implemented calorie labeling (July 2015–January 2017) and 4 after (July 2017–January 2019). Each timepoint included a complete record of all products (total of 94,718 unique items) sold at the 2 chains, including products' Universal Product Code, description, serving size, calorie content, and calorie labeling status. Products' Universal Product Codes were used to identify unique products and track products over time.

Guiding Stars oversaw implementation of calorie labels at the chains. Analyses classified products as prepared foods if Guiding Stars designated the product as being subject to the new calorie labeling requirement or if product characteristics met criteria for labeling based on the Food and Drug Administration's guidance.³⁹ Appendix Text 1 provides additional details. Analyses stratified prepared foods into 3 categories, reflecting that consumers might respond differently to calorie labels depending on food type^{25,31–34} (and thus companies might reformulate differently): (1) fresh bakery items (e.g., muffins), (2) entrees and sides (e.g., rotisserie chicken, hereafter "entrees"), and (3) deli meats and cheeses (e.g., freshly sliced turkey). Foods were categorized using a previously developed food grouping

system^{35,40} combined with product category variables available in the Guiding Stars data (Appendix Table 2). For example, entrees were defined as products in the “Convenience foods–cold” or “Pizza” or “Soup” food groups or the “Deli,” “HMS” (an abbreviation for store brand prepared foods), or “HMS commissary” Guiding Stars product categories. These 3 food categories comprised 88% of the prepared foods sold at the 2 chains. The remaining prepared foods were unlikely to be reformulated and included produce (e.g., pre-sliced fruit); condiments, sauces, and dressings (e.g., mustard); and whole seafood (e.g., lobsters); these categories were examined in exploratory analyses.

Analyses identified comparison foods in each of the food categories that were similar to prepared foods (i.e., were in the same food groups or Guiding Stars categories), but that were not subject to the new labeling requirement because they were packaged foods that already display calorie information on a Nutrition Facts label.

Previous studies of calorie labeling in restaurants have found that changes in calorie content may differ for items that are continuously offered compared with items that are newly introduced.^{41–44} Primary analyses focused on continuously available products to allow for examination of potential reformulation of the same products over time. Continuously available items were defined as those sold at all 8 study timepoints. Exploratory analyses examined newly introduced products, defined as those introduced after July 2015, the first study timepoint. A product was considered newly introduced only once, during the timepoint in which it was first available.

The primary outcome was products’ total calorie content (calories/item), calculated as calories/serving multiplied by servings/item. This outcome reflects the number of calories consumers take home when they purchase a product and is therefore the outcome most relevant for public health. Secondary outcomes were energy density (calories/100 grams) and product size (grams/item), the 2 potential mechanisms through which companies can change products’ calorie content. Calorie and serving information came from the Guiding Stars database; for about 11% of products in the analytic sample, research staff used company/product websites to fill in missing data on these variables.

Statistical Analysis

Prior to conducting analyses, the analysis plan was pre-registered at AsPredicted.org (aspredicted.org/blind.php?x=z7dg8j). Deviations from this plan are detailed in Appendix Text 2.

The analytic sample for primary analyses of bakery, entrée, and deli items excluded observations that were not food (e.g., pet food), were not rated by Guiding Stars (e.g., products used as ingredients and not sold to consumers, products with variable nutritional content), were implausibly listed as having 0 calories, or did not have information on calories/item (Appendix Figure 1 depicts a flowchart of exclusions). To reduce the influence of extreme values, which may not represent typical products, primary analyses additionally excluded items that had calorie content 99th percentile in each food group; products excluded because of outlying calorie content were items meant for large gatherings such as sheet cakes or sandwich platters. The final analytic sample included 46,528 product-by-

timepoint observations from continuously available foods (from 5,816 unique items) and 6,765 product-by-timepoint observations from newly introduced foods (from 6,765 unique items). Missingness on the primary outcome (10% of observations) (Appendix Figure 1) did not appear to be differential with respect to time and prepared versus comparison status (Appendix Table 3). About 13% of continuously available foods and 4% of newly introduced foods were missing data on secondary outcomes (Appendix Table 4).

Primary analyses of continuously available items estimated the association of calorie labeling with product calorie content using a difference-in-differences (DD) approach,⁴⁵ comparing change in outcomes from pre- to post-labeling among prepared foods with the contemporaneous change in outcomes among comparison foods. Analyses estimated linear mixed models to account for repeated observations within products, treating the intercept as random. Prior to fitting final models, analyses examined whether pre-implementation trends in calorie content were parallel between prepared and comparison items by fitting mixed models with an interaction between prepared status and timepoint.⁴⁵ Models suggested different pre-implementation trends for prepared and comparison deli items ($p < 0.001$ for interaction), but not for bakery items ($p = 0.14$) or entrees ($p = 0.06$) (Appendix Table 5). All models included a linear trend for calorie content over time, and for analyses of deli items, this trend was allowed to differ by prepared status. The DD estimate thus represents how prepared foods changed from pre- to post-labeling net of contemporaneous changes among comparison foods and after accounting for pre-labeling trends in outcomes.

Exploratory analyses examined changes in calorie content of continuously available produce, seafood, and condiments, using the same analytic approach as primary analyses.

Five sensitivity analyses were conducted: (1) using product-level fixed effects instead of random effects, (2) including outlying observations with very high calorie content (99th percentile), (3) excluding products with uncertain prepared status, (4) allowing pre-implementation trends to differ between prepared and comparison foods for bakery items and entrees, and (5) separating changes in calorie content into changes over two periods—after the chains implemented labeling but before the national implementation date (between April 2017 and May 2018) and after the national implementation date of May 2018.

Exploratory analyses examined changes in outcomes among newly introduced items using a similar DD approach. Analyses of newly introduced items used median regression, a type of quantile regression,⁴⁶ given the wide variance and skewed nature of the outcomes among newly introduced items. Analyses revealed some evidence of differential trends between prepared and comparison items (though trends were imprecisely estimated) (Appendix Table 6); models allowed trends in outcomes to differ between prepared and comparison items.

Analyses were conducted in Stata MP, version 16. This study was deemed exempt from human subjects review.

RESULTS

In the pre-implementation period, continuously available prepared bakery items were higher in calories than comparison items (Table 1). The opposite was true for entrees and for deli meats and cheeses.

After labeling implementation, calorie content of prepared bakery items decreased by 7.7 calories/item relative to changes among comparison bakery items (95% CI= -12.9, -2.5, $p=0.004$) (Figure 1, Table 2), an approximately 0.5% reduction from the pre-implementation mean. Implementation of calorie labeling was not associated with changes in calorie content of prepared entrees (DD= +2.6 calories/item, 95% CI= -1.4, 6.7, $p=0.20$) or deli items (DD= +0.3 calories/item, 95% CI= -10.1, 10.7, $p=0.95$). Exploratory analyses of produce, seafood, and condiments did not find associations between calorie labeling and changes in calorie content ($p>0.56$ for all) (Appendix Table 7).

Sensitivity analyses revealed similar results. DDs were nearly identical to primary analyses when using product-level fixed effects, excluding products with uncertain prepared status, including differential trends for prepared and comparison items, and separately examining chain versus national labeling implementation dates (Appendix Table 8). One difference was that when including observations with calorie content 99th percentile, the association between calorie labeling and calorie content among prepared bakery items became imprecisely estimated and not statistically significant.

In analyses of secondary outcomes, calorie labeling was not associated with changes in energy density or product size among bakery or deli items (Table 2). Prepared entrees increased in energy density after labeling relative to comparison items (DD= +1.3 calories/100 grams, 95% CI=0.4, 2.2, $p=0.004$), but this increase was offset by a decrease in product size (DD= -2.0 grams/item, 95% CI= -3.3, -0.6, $p=0.005$).

During the pre-labeling period, newly introduced prepared bakery items, entrees, and deli items were higher in calories than comparison items (Appendix Table 9).

Prepared bakery items introduced after labeling were lower in calorie content than those introduced before labeling, relative to changes in comparison items (DD= -440.0 calories/item, 95% CI= -773.9, -106.1, $p=0.01$) (Table 3). By contrast, changes were not observed from pre- to post-labeling in the calorie content of newly introduced prepared entrees (DD= +186.9, 95% CI= -12.2, 386.0, $p=0.07$) or deli items (DD= -338.0, 95% CI= -850.3, 174.2, $p=0.20$).

Prepared bakery items introduced after labeling were smaller than those introduced before labeling (DD= -278.0 grams/item, 95% CI= -381.1, -174.9, $p<0.001$) (Table 3), whereas entrees were larger (DD= +130.3, 95% CI=19.1, 241.6, $p=0.02$). Analyses did not find changes in product size among prepared deli items, or in energy density among prepared foods of any category.

DISCUSSION

In this quasi-experimental study of 2 large supermarket chains, analyses revealed small declines in calorie content of continuously available prepared bakery items after implementation of calorie labeling ($\approx 0.5\%$ reduction) and larger declines in calorie content of newly introduced bakery items ($\approx 27\%$ reduction). Such supply-side changes could have important public health implications, as they could reduce calorie consumption by default, without requiring consumers to change their behavior. Although these data preclude estimating changes in calorie purchases or intake, an observational study found that modest product reformulation (about 3%–17% reductions in energy density, depending on food group) led to declines of up to 7.5% in calories purchased from these foods.⁴⁷ Because prepared foods contribute a large portion of Americans' calorie intake,² labeling-induced product reformulation leading to even small reductions in calorie intake could potentially affect population-level outcomes like obesity prevalence.^{48–53}

Exploratory analyses suggested a reduction of approximately 27% in the calorie content of newly introduced bakery items after implementation of calorie labels. This reduction is similar in magnitude to differences in calorie content of newly introduced menu items observed between restaurants that did versus did not implement voluntary calorie labels prior to these labels becoming mandatory.⁴⁴ This study, the first to examine prepared foods in supermarkets, suggests that retailers might be more inclined to reduce calorie content among new items than among products about which consumers already have expectations. Supply chain complexities, such as the length of vendor contracts or supplier contracts with multiple retailers, could also make it more expensive for retailers to reduce calories in existing products than to offer new, lower-calorie products. The exploratory nature of these analyses warrant confirmation in larger studies, which will become possible as retailers introduce more prepared foods to the marketplace.

The observed reductions in calorie content of prepared bakery items could be achieved by changes in energy density and product size. Analysis did not reveal changes in energy density or product size for continuously available prepared bakery items, potentially owing to smaller sample size in these analyses. Exploratory analyses of newly introduced items suggested large reductions in prepared bakery items' size after labeling, which could contribute to lower calorie intake.⁹ However, the present analyses cannot determine if customers will buy more items to offset smaller product sizes.

Although prepared bakery items became lower in calorie content after labeling, the calorie content of deli items did not change for either continuously available or newly introduced items. Similarly, continuously available prepared entrees became more energy dense, but this change was offset by a reduction in product size, leading to no net change in calories. Newly introduced entrees became larger but did not exhibit a net increase in calories. One explanation for these differences in findings across product categories could be that retailers anticipate that consumers will respond differently to calorie labels on different foods,^{25,31–34} creating differing incentives to reformulate across categories. Another possibility is that bakery items are more amenable to reformulation than other foods. Additional strategies may be needed to encourage calorie reduction across more product categories.

This study's findings that calorie labeling was associated with reductions in calorie content of prepared bakery items, and not associated with increases in calorie content of any foods, support continued implementation of calorie labels for supermarket prepared foods, because the observed reductions could yield health benefits even in the absence of changes in consumer behavior. However, the absence of calorie reduction among entrees and deli items suggests that additional nutrition labeling policies might be needed to encourage more substantial and widespread reformulation. For example, the U.S. could explore nutrient-based warnings for products that exceed certain thresholds for unhealthy nutrients.⁵⁴ These "high in" warnings have been implemented in several Latin American countries and appear to spur substantial reductions in sugar and sodium content in foods and beverages.³⁰

Limitations

Strengths of this study include the use of objective data on calorie content and examination of supermarkets, an important but understudied source of prepared foods. There were several limitations. First, labeling status was not randomly assigned. However, to improve causal inference, analyses used a DD approach, comparing prepared foods to a control group of similar foods whose labeling did not change after calorie labeling implementation. Second, analyses did not examine food purchases or intake. Third, some products had missing data. Missing data on the primary outcome was similar over time within intervention groups, and therefore are unlikely to have affected DD estimates. Higher missingness for secondary outcomes may have reduced power to detect changes in potential mechanisms for reformulation. Fourth, analyses lacked sufficient sample size to examine discontinued items; future studies should assess whether retailers discontinue high-calorie prepared items after calorie labeling.⁴³ Fifth, companies may have reformulated products prior to the study period (after the labeling requirement had been announced but before it was implemented), which could bias this study's estimates of labels' effects toward the null. Similarly, analyses included 2 years of follow-up; companies might change products in the future, and longer follow-up periods are warranted. Finally, results may not generalize to other chains.

CONCLUSIONS

Calorie labeling policies may encourage beneficial reformulation among some types of prepared supermarket foods. The U.S. should continue to implement calorie labels. Future research should prioritize understanding how consumer demand responds to calorie labels and any accompanying changes in the nutritional quality of the food supply⁵⁵ or product marketing, and how these changes affect diet and health.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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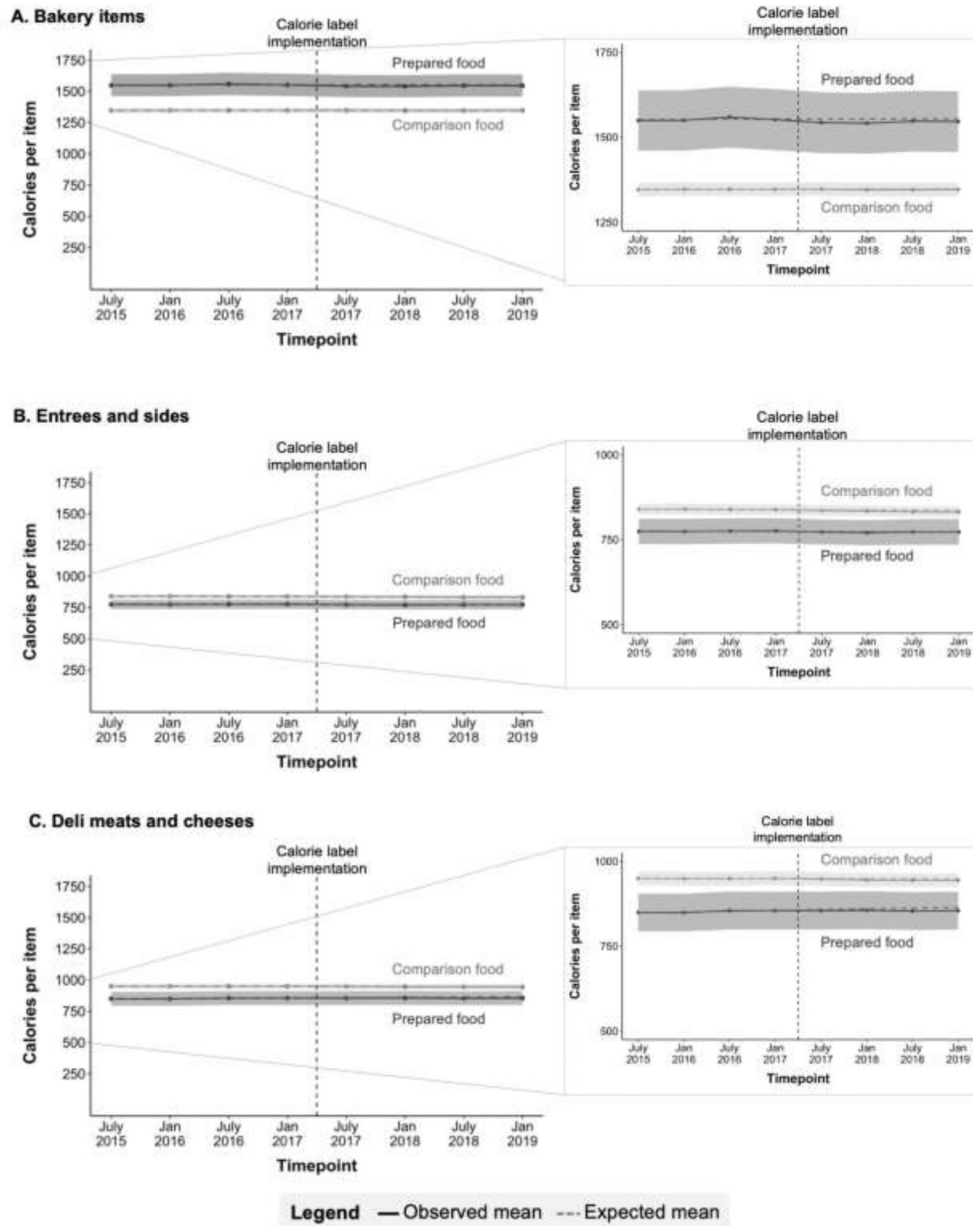


Figure 1. Calorie content of continuously available foods before and after implementation of calorie labeling.

Notes: The horizontal solid lines show observed mean calories per item. The shaded regions around these solid lines show SEs (± 1 SE) around the observed mean calories per item. The horizontal dotted lines show expected mean calories per item in the absence of calorie labeling (i.e., projections of pre-labeling trends). The vertical dotted line shows the timing of calorie labeling implementation in the chains (April 2017). Prepared foods were items subject to the new calorie labeling requirement; comparison foods were packaged products similar to prepared items but not subject to the new calorie labeling requirement. Bakery items were muffins, pastries, bagels, biscuits, cookies, and rolls. Entrees and sides were

main course items or side dish items such as rotisserie chicken, sandwiches, chicken wings, pizza, macaroni and cheese, potato salad, and soups. Deli meats and cheeses were pre-sliced deli meats such as turkey, ham, or chicken breast or pre-sliced deli cheeses.
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Table 1.

Pre-labeling Characteristics of Continuously Available Bakery Items, Entrees and Sides, and Deli Meats and Cheeses Sold at 2 Supermarket Chains

Characteristic	Bakery items		Entrees and sides		Deli meats and cheeses	
	Prepared, <i>n</i> =165	Comparison, <i>n</i> =1,663	Prepared, <i>n</i> =293	Comparison, <i>n</i> =2,451	Prepared, <i>n</i> =79	Comparison, <i>n</i> =1,140
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Total calories (calories/item)	1,552 (1,143)	1,347 (809)	774 (634)	833 (786)	852 (495)	949 (683)
Energy density (calories/100 grams)	339 (82)	401 (79)	178 (51)	218 (113)	255 (128)	308 (123)
Product size (grams/item)	496 (382)	350 (248)	441 (353)	434 (334)	355 (163)	329 (232)

Notes: *ns* refer to number of unique products. The pre-labeling period refers to July 2015 through January 2017; the chains implemented calorie labels in April 2017. Prepared foods were items subject to the new calorie labeling requirement; comparison foods were packaged products similar to prepared items but not subject to the new calorie labeling requirement. Bakery items were muffins, pastries, bagels, biscuits, cookies, and rolls. Entrees and sides were main course items or side dish items such as rotisserie chicken, sandwiches, chicken wings, pizza, macaroni and cheese, potato salad, and soups. Deli meats and cheeses were pre-sliced deli meats such as turkey, ham, or chicken breast or pre-sliced deli cheeses.

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Table 2.

Association of Implementation of Calorie Labeling With Changes in Mean Total Calories, Energy Density, and Product Size Among Continuously Available Prepared Foods

Food type	Total calories (calories/item)	Energy density (calories/100 grams)	Product size (grams/item)
	B (95%CI)	B (95%CI)	B (95%CI)
Bakery items, <i>n</i> =1,828	-7.7 (-12.9, -2.5)	-0.3 (-1.6, 1.1)	0.7 (-0.7, 2.1)
Entrees & sides, <i>n</i> =2,769	2.6 (-1.4, 6.7)	1.3 (0.4, 2.2)	-2.0 (-3.3, -0.6)
Deli meats & cheeses, <i>n</i> =1,219	0.3 (-10.1, 10.7)	0.5 (-3.8, 4.7)	-0.6 (-5.8, 4.6)

Notes: *ns* refer to unique products included in analyses of the primary outcome, total calories. Table shows unstandardized regression coefficients (B) and 95% CIs for difference-in-differences estimates of the effect of calorie labeling, comparing change in outcomes from pre- to post-labeling among prepared foods compared to change from pre- to post-labeling among comparison foods. Analyses of continuously available items included data from July 2015 through January 2019; the chains implemented calorie labels in April 2017. Analyses estimated linear mixed models to account for repeated observations, treating the intercept as random. Analyses of secondary outcomes (calories/100 grams and grams/item) included fewer observations due to missing data on those outcomes; Appendix Table 4 shows the number of unique products included in analyses of each outcome. Boldface indicates statistically significant coefficients ($p < 0.05$). Prepared foods were items subject to the new calorie labeling requirement; comparison foods were packaged products similar to prepared items but not subject to the new calorie labeling requirement. Bakery items were muffins, pastries, bagels, biscuits, cookies, and rolls. Entrees and sides were main course items or side dish items such as rotisserie chicken, sandwiches, chicken wings, pizza, macaroni and cheese, potato salad, and soups. Deli meats and cheeses were pre-sliced deli meats such as turkey, ham, or chicken breast or pre-sliced deli cheeses.

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Table 3.

Association of Implementation of Calorie Labeling With Changes in Median Total Calories, Energy Density, and Product Size Among Newly Introduced Prepared Foods

Food type	Total calories (calories/item)	Energy density (calories/100 grams)	Product size (grams/item)
	B (95%CI)	B (95%CI)	B (95%CI)
Bakery items, <i>n</i> =2,078	-440.0 (-773.9, -106.1)	11.7 (-25.2, 48.5)	-278.0 (-381.1, -174.9)
Entrees & sides, <i>n</i> =3,465	186.9 (-12.2, 386.0)	-23.7 (-63.6, 16.2)	130.3 (19.1, 241.6)
Deli meat & cheese, <i>n</i> =1,213	-338.0 (-850.3, 174.2)	25.0 (-126.0, 175.9)	-9.4 (-129.3, 110.5)

Notes: *ns* refer to unique products included in analyses of the primary outcome, total calories. Table shows unstandardized regression coefficients (B) and 95% CIs for difference-in-differences estimates of effect of calorie labeling, comparing change in outcomes from pre- to post-labeling among prepared foods compared to change over time among comparison foods. Analyses of newly introduced items included data from January 2016 through January 2019; the chains implemented calorie labels in April 2017. Analyses used median regression to account for highly skewed outcomes. Analyses of secondary outcomes (calories/100 grams and grams/item) included fewer observations due to missing data on those outcomes; Appendix Table 4 shows the number of unique products included in each analysis. Boldface indicates statistically significant coefficients ($p < 0.05$). Prepared foods were items subject to the new calorie labeling requirement; comparison foods were packaged products similar to prepared items but not subject to the new calorie labeling requirement. Bakery items were muffins, pastries, bagels, biscuits, cookies, and rolls. Entrees and sides were main course items or side dish items such as rotisserie chicken, sandwiches, chicken wings, pizza, macaroni and cheese, potato salad, and soups. Deli meats and cheeses were pre-sliced deli meats such as turkey, ham, or chicken breast or pre-sliced deli cheeses.

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