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The effect of ingredient-specific calorie information on calories ordered

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ABSTRACT

Providing calorie labeling is a widely used strategy to combat obesity. However, there is little evidence that the availability of calorie information at food-away-from-home establishments has an effect on food choices. Listing calorie information for each ingredient, though, may allow customers to avoid high-calorie items that add little to their enjoyment. Data from a natural experiment were used to compare total calories ordered before and after the provision of per-ingredient versus for build-your-own sandwiches, and per-sandwich for pre-defined sandwiches, at a supermarket sandwich counter.

Sandwich order slips from a Lincoln, Neb. supermarket were collected from December 15, 2016 to February 4, 2018. In June 2017, calorie information was introduced. A total of 1134 build-your-own orders and 559 pre-defined orders were collected.

Calories ordered before and after the provision of calorie information were examined for build-your-own and pre-defined sandwiches using two-sample *t*-tests. Orders post-calorie information were split into three periods to examine whether responses to information changed over time. Ingredients ordered were also examined before and after information was provided.

Customers decrease calories ordered by 7.8% for build-your-own sandwiches when per-ingredient calorie information is introduced. There is no significant change in calories ordered for pre-defined sandwiches. Calorie reduction appears to result from substitution away from some higher calorie items, e.g., mayonnaise, towards lower calorie ingredients, like mustard. Despite low calorie content, customers did not increase the number of vegetables ordered. Finally, there is no attenuation of the effect of calorie information over time.

1. Introduction

A common policy response to the US obesity epidemic, which is frequently attributed to overconsumption of unhealthy foods, has been to increase the amount of nutrition information available to consumers in order to allow them to make healthier choices. Increasing consumption of food-away-from-home (FAFH) motivated nutrition information regulations—introduced in the Affordable Care Act (Section 4205 [March 2010])—for restaurants with 20 or more locations (Kant and Graubard, 2004; National Restaurant Association, 2015; Center for Science in the Public Interest, 2018). The rule, requiring food retailers to post calorie amounts and to make available information about other nutrients upon request, was implemented May 7, 2018. However, data from early adopters provide evidence of the effectiveness of calorie labeling in FAFH settings. Some studies find small, significant reductions in calories ordered (Bassett et al., 2008; Wisdom et al., 2010; Bollinger et al., 2011; Ellison et al., 2013), while others find no change (Elbel et al., 2009; Finkelstein et al., 2011; Tandon et al., 2011; Cantor et al., 2015). Meta-analyses of calorie labeling in FAFH settings do not find systematic evidence that calorie labeling changes behavior (Kiszko et al., 2014; Sinclair et al., 2014; Long et al., 2015; Littlewood et al., 2016; VanEpps et al., 2016; Bleich et al., 2017; Cantu-Jungles et al., 2017).

A handful of studies on food choice suggest that making healthier options more salient—through informational framing, prompting people to explicitly consider their health, or behavioral economic nudges—increases the probability that individuals choose a healthier item (Cantor et al., 2015). Highlighting key nutrients or a summary nutritional score appears to promote healthier behavior (Kiesel and Villas-Boas, 2013; Cawley et al., 2015; Fernandes et al., 2016; Zhu et al., 2016), particularly if the decision-maker faces constraints, such as limited time availability, when making food choices (Crosetto et al., 2016).

Interventions in the FAFH environment that are informed by behavioral sciences have not been uniformly successful. For instance, per-meal or per-day calorie recommendations combined with calorie

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information seems, if anything, to slightly increase the number of calories ordered (Downs et al., 2013). However, making healthier choices easier shows more promise. Making the healthier option slightly more convenient reduces the number of calories ordered (Cantor et al., 2015). Inviting customers in a fast-food restaurant to reduce their portion size in order to decrease the number of calories ordered leads to a significant drop in the number of calories consumed by customers who accept the offer (Schwartz et al., 2012). Using heuristic-based labels, such as traffic lights or letter grades, and purposefully organizing calorie information to facilitate easy comparison among food options is also found to engender lower-calorie choices (Downs et al., 2015). The implications of the latter two findings are particularly important for policies using information to affect lower-calorie choices, given cognitive capacity limitations that may constrain the processing of complex information (Marois and Ivanoff, 2005).

Individuals' food preferences play a fundamental role in choice (Shepherd and Raats, 2006). Research suggests that taste registers more quickly than health when people evaluate food choices, particularly for individuals with lower self-control (Sullivan et al., 2015). The choices of individuals prompted to consider taste attributes do not differ from choices of individuals in a no-prompt condition while choices in a health prompt condition do differ (Hare et al., 2011), implying that people more naturally consider taste than health. Given that people frequently make food choices quickly and without fully engaging conscious, critical thought processes (Rangel, 2013), it may not be sufficient to simply provide calorie information to change food consumption patterns.

Providing detailed information on the calories contributed by each ingredient, an alternative approach to whole-item calorie labeling, may help change behavior in the face of strongly held food preferences. Per-ingredient calorie labeling could help customers avoid high-calorie items that contribute relatively little to their enjoyment, while keeping attributes that are most important to them (Schwartz et al., 2014). For example, per-ingredient calorie labeling would identify an easy opportunity to reduce caloric intake for a consumer who does not care much about the cheese on a bacon cheeseburger by highlighting the number of calories she could avoid by forgoing the cheese.

This article compares the effect of per-ingredient calorie labeling with the traditional per-item calorie labeling on the number of calories ordered. We use data from a natural experiment—the voluntary implementation of calorie labeling at a supermarket sandwich counter in Lincoln, Nebraska. Two types of sandwiches are available: 1) build-your-own sandwiches (BYO), with calorie information provided per ingredient, and 2) pre-defined sandwiches (DEF), with calorie information provided for the entire sandwich (the ingredients in each of the six DEF sandwiches were always displayed). For BYO sandwiches, customers select ingredients from the following categories: bread, protein, cheese, spreads, and vegetables.

We examine changes in calories ordered per sandwich after calorie labeling was introduced in BYO and DEF sandwiches. Ingredient-specific calorie information may highlight opportunities to make marginal—substituting or omitting ingredients—rather than extensive changes from one sandwich to another.

2. Methods

Customers order sandwiches on a paper slip, which employees use to prepare the sandwich. The store provided the researchers with order slips documenting customers' choices before and after calorie information was made available. The price of sandwiches was identical throughout the study period. After calorie information was introduced, BYO sandwiches presented calorie information for each ingredient customers could select from and DEF sandwiches presented calorie information for the entire sandwich. Our dataset includes 1679 orders of BYO and DEF sandwiches from December 15, 2016 to February 4, 2018. The period of time before calorie information was introduced (PRE) lasted from December 15, 2016 to June 15, 2017. Calorie information was available when customers ordered sandwiches (POST) from June 16, 2017 to February 4, 2018.

We calculated the number of calories ordered per sandwich during PRE and POST periods using calorie information provided in the POST period. We examine differences in means using a two-sample *t*-test to estimate the effect of calorie information on the number of calories ordered for BYO and DEF in PRE and POST time periods. A number of studies suggest that changes in behavior resulting from interventions may be short-lived (Cantu-Jungles et al., 2017; Allais et al., 2017). To evaluate the persistence of effects, we divide the POST timeframe into three periods: from implementation of calorie labeling in mid-June to mid-September, (POST1), from mid-September to mid-December (POST2), and from mid-December 2017 to early February 2018 (POST3).[1]

We first analyze calories ordered for BYO and DEF in PRE and POST time periods. We then disaggregate POST into POST1, POST2, and POST3 and estimate calories ordered in PRE, POST1, POST2, and POST3 to examine whether there is evidence that the response to calorie information attenuates over time. Finally, we examine ingredient-specific ordering patterns for BYO sandwiches in PRE and POST periods to evaluate how patterns change after introduction of calorie information (e.g., substitute lower-calorie items for high-calorie items; decided to skip high-calorie ingredients such as cheese, or decided to consume only one slice of cheese instead of two or more). The list of ingredients in the POST period contains all the ingredients presented in the PRE period. We examine differences in ordering patterns PRE and POST time periods using a two-sample *t*-test. Data were analyzed using STATA/MP 14.2 Statistical Software (StataCorp, 2017). We consider p-values < 0.05 to be statistically significant.

3. Results

We find a significantly larger decrease in the number of calories ordered for BYO sandwiches after the implementation of calorie labeling than for DEF sandwiches (Table 1). The average number of calories ordered for BYO sandwiches fell from 812.7 in PRE to 750.1 in POST ($p < 0.01$), a nearly 8% reduction in the number of calories ordered. DEF sandwiches, on the other hand, experience no change.

Next, we examine whether the effect of calorie information diminishes over time by examining the mean calories ordered per sandwich in PRE, POST1, POST2, and POST3. We find an almost identical drop in calories for BYO sandwiches between PRE and POST1 as we estimated for PRE and POST. The number of calories ordered per sandwich decreases from 812.7 in PRE to 748.5 in POST1 ($p < 0.01$), 759.5 in POST2 ($p < 0.01$), and 739.7 in POST3 ($p < 0.01$), which represents a 7.9%, 6.5%, and 9.0% reduction in the number of calories ordered, respectively. The differences in calories ordered per sandwich between POST1, POST2, and POST3 are not statistically significant. We do not find any statistically significant differences in any time periods for DEF sandwiches.

We next examine ingredient-specific ordering patterns for BYO sandwiches in PRE and POST periods to understand how customers' orders changed (Table 2). Statistically significant changes occur in customers' ordering patterns in almost every ingredient category. Customers not selecting a protein fell from 6.1% in PRE to 2.7% in POST ($p < 0.01$). There is both an increase in customers forgoing cheese altogether, from 11.8% in PRE to 13.2% in POST and a decrease in customers ordering two or more cheeses, falling from 4.3% in PRE to 1.6% in POST ($p < 0.01$). Jointly, these behaviors created a significant drop in the average number of slices of cheese ordered per sandwich, from 0.94 in PRE to 0.89 in POST ($p < 0.05$). Ordering patterns for

[1] We alternatively split the follow-up into two time periods: mid-June through September, and October through February. The results do not change.

Table 1
Calories ordered for BYO and DEF sandwiches before and after implementation of calorie labeling.
Source: Sandwich order data.

	Mean (calories)	[95% conf. interval] (calories)	p-Value	Number of observations
Build your own sandwich (BYO)				
All	771.7	[762.5–780.8]		1134
PRE	812.7	[796.5–828.8]	$p < 0.01$	391
POST	750.1	[739.4–760.8]		743
All	771.7	[762.5–780.8]		1134
PRE	812.7	[796.5–828.8]	$p < 0.01$	391
POST 1	748.5	[732.2–764.9]		316
POST 2	759.5	[739.5–779.4]	$p < 0.01$	249
POST 3	739.7	[719.8–759.6]	$p < 0.01$	178
Signature sandwiches (DEF)				
All	971.3	[951.1–991.4]		545
PRE	969.6	[941.8–997.3]		292
POST	973.2	[943.7–1002.7]		253
All	971.3	[951.1–991.4]		545
PRE	969.6	[941.8–997.3]		292
POST 1	995.6	[949.0–1042.2]		116
POST 2	960.1	[911.5–1008.8]		77
POST 3	946.8	[885.7–1007.9]		60

Table 2
Ordering patterns for build-your-own sandwiches before and after the introduction of per-ingredient calorie information.
Source: Sandwich order data.

			PRE	POST	% change	
All	Orders	Number	390.0	744.0		
Bread	Pieces per order	# of pieces	1.0	1.0	0%	
	No bread[a]	Percentage	0.8	0.1	−88%	*
Protein	Pieces per order	# of pieces	1.08	1.09	1%	
	More than one protein	Percentage	13.0	11.4	−12%	
	No protein	Percentage	6.1	2.7	−56%	***
Cheese	Pieces per order	# of pieces	0.94	0.89	−5%	**
	More than one cheese	Percentage	4.3	1.6	−63%	***
	No cheese	Percentage	11.8	13.2	12%	
Veggies	Pieces per order	# of pieces	2.51	2.23	−11%	***
	More than one veggie	Percentage	73.7	75.8	3%	
	No veggies	Percentage	5.1	9.7	90%	***
Spread	Pieces per order[b]	# of pieces	1.09	1.07	−2%	
	More than one spread	Percentage	17.4	22.9	32%	**
	No spread	Percentage	13.0	21.7	67%	***

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.
[a] Bread can be substituted by a lettuce wrap.
[b] A piece of bread is 100 g (=two slices); a piece of protein is either 4 oz. of fresh (e.g., turkey, roast beef) or 2 oz. of preserved (bacon, prosciutto) meat; a piece of cheese is a one-oz. slice; a piece of veggie is 1 oz; and a spread is normally 2 tablespoons of solid dressings (mustard, mayonnaise), or 1 tablespoon of liquid (oil, vinegar).

spreads work in opposite directions. There is both an increase in customers ordering more than one spread (from 17.4% to 22.9%, $p < 0.05$) and in customers not ordering a spread (from 13.0% to 21.7%, $p < 0.01$). Finally, the number of vegetables ordered per sandwich fell after the implementation of calorie labeling, from 2.51 to 2.23 ($p < 0.01$). While these findings identify changes in within-category ordering patterns, items within a category may have markedly different calorie contents. For instance, the spread category ranged from five (mustards and vinegar) to 180 cal (mayonnaise). Therefore, we next look at changes within each category to identify how the addition of calorie information led to a decrease in calories ordered (Table 3).

We observe little change in ordering patterns in the bread category.

Table 3
Ingredient-specific ordering patterns before and after the introduction of calorie information for build-your-own sandwiches.
Source: Sandwich order data.

		Calories	PRE	POST	% change	
Bread	Sourdough	270	27.9	24.8	−11%	
	Ciabatta	280	25.0	24.7	−1%	
	Multigrain ciabatta	310	8.1	12.7	57%	**
	9-Grain	280	26.2	23.3	−11%	
	Marble rye	260	12.8	14.6	14%	
Protein	Roast beef	170	22.4	25.7	15%	
	Roast or smoked turkey	300	67.3	54.2	−19%	***
	Salami	200	4.5	7.3	62%	*
	Ham	210	11.2	18.8	68%	***
Cheese	Cheddar	110	32.2	39.5	23%	**
	Provolone	110	30.7	36.4	19%	*
	Swiss	120	26.3	19.4	−26%	**
	Mozzarella (fresh or smoked)	180	15.2	7.6	−50%	***
Veggies	Lettuce or mixed greens	10	68.6	59.0	−14%	***
	Tomato	5	60.8	67.3	11%	**
	Red onion	15	41.7	45.0	8%	
	Spinach	5	40.9	41.7	2%	
Spread	Yellow mustard	5	9.9	15.1	53%	**
	Dijon mustard	5	22.0	34.0	55%	***
	Mayonnaise (any kind)	180	76.5	48.8	−36%	***
	Olive oil	120	7.7	15.3	99%	***
	Red wine vinegar	5	2.8	23.2	729%	***

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

The only significant change from PRE to POST occurred for multigrain ciabatta. Although one of the higher calorie bread options, orders including multigrain ciabatta increased from 8.1% to 12.7% ($p < 0.05$). More change occurred in protein choices. Here, customers seemed to substitute ham for turkey. Customers ordering turkey decreased from 67.3% to 54.2% ($p < 0.01$), while ham was ordered more frequently. The slips indicated that turkey contained 300 cal per sandwich, while ham contained 200 cal. The pattern of cheese orders exhibits a strong and consistent shift from higher to lower calorie cheeses with the introduction of calorie information. Customers shifted away from Swiss and mozzarella and towards Cheddar.

Customers changed the spreads they requested after the introduction of calorie information, resulting in a significant decrease in calories ordered. Customers increased orders of yellow mustard and Dijon mustard. Orders increased markedly for olive oil, from 7.7% to 15.3% ($p < 0.01$), and red wine vinegar, from 2.8% to 23.2% ($p < 0.01$). Mayonnaise requests, however, decreased substantially, from 76.5% of orders to 48.8% of orders ($p < 0.01$). Finally, among vegetables, we see a modest decrease in orders requesting lettuce or mixed greens, from 68.6% to 59.0% ($p < 0.01$), and an increase in orders requesting tomato, from 60.8% to 67.3% ($p < 0.05$).

4. Discussion

We exploit a natural experiment—the introduction of calorie information at a supermarket sandwich counter—to test the effect of the presentation of calorie information. Calorie information was presented in different formats for two sandwich types. In the first, calorie information was provided for each ingredient for build-your-own sandwiches (BYO). In the second format—which reflects the standard approach to calorie labeling—a total calorie count was provided for sandwiches with a pre-defined set of ingredients (DEF).

The number of calories customers ordered after the introduction of calorie information did not change for DEF sandwiches, which corroborates findings from previous studies and meta-analyses of the effect of calorie labeling in FAFH settings (Elbel et al., 2009; Tandon et al., 2011; Cantor et al., 2015; Littlewood et al., 2016; Bleich et al., 2017; Cantu-

Jungles et al., 2017). However, when ingredient-specific calorie information was provided, the number of calories ordered in BYO sandwiches decreased significantly, by nearly 8% per sandwich. While some studies have found decreases in the number of calories ordered when calorie information is introduced, these studies usually feature direct interaction between the researcher and the research subject, which may influence subjects' behavior through demand effects (Downs et al., 2013; Cantor et al., 2015; Downs et al., 2015). Unlike other interventions targeting behavior change (e.g., Cantu-Jungles et al., 2017; Allais et al., 2017), we find that the effects of per-ingredient calorie information are sustained over an eight-month follow-up period. In fact, there is no attenuation of the effect of per-ingredient calorie information on calories ordered, which suggests that per-ingredient calorie labeling sustains behavior change.

The data also permitted us to examine how ingredient ordering patterns changed after calorie information was introduced. While there were significant changes in every ingredient category, we observed a consistent pattern of decreasing orders of high-calorie items and increases in choices of low-calorie items. However, certain results suggest that a focus on calorie information may lead customers to choose products that are less caloric but not necessarily healthier, highlighting the need for further research.

The biggest changes occurred in the meat/protein, cheese, and spread categories. For instance, customers shifted away from mayonnaise and towards mustards, vinegar, and olive oil in the spread category. Mustard and vinegar are low-calorie options. Olive oil, with 120 cal per serving, is not, though it is less caloric than mayonnaise (180 cal/serving); additionally, olive oil has a reputation for being a healthy oil, which may have tempered customers' desire to avoid it. Another important change worth mentioning is the decrease in the percentage of customers ordering turkey while a higher percentage of customers ordered ham. This may result from disparities between customers' expectations of the healthiness of turkey and ham and the calorie information provided. Information solely about calories may lead customers to choose a lower calorie, but less healthy option over a higher calorie, but healthier option as, in general, ham contains much more sodium than turkey.

We document only modest changes in ordering in bread and vegetable categories, although changes in these categories suggest that customers' pre-information expectations of calorie amounts may influence their response to information. For instance, the highest calorie bread, multigrain ciabatta, was ordered more frequently after calorie information was provided. However, the difference between the highest and lowest calorie breads was only 50 cal, and multigrain breads are frequently touted as healthier options than highly processed white breads. The results suggest that providing calorie information alone, instead of a complete picture of the nutritional quality of food items, may be driving people away from high calorie items that are healthier overall towards unhealthier, but less caloric items. However, more research needs to be done to have a clearer picture of the effects on calorie information on healthiness of food choices. While calorie information does not represent a universal measure of the healthfulness of food items, these results are noteworthy in the context of the literature on calorie labeling and provide a unique comparison between the effectiveness of calorie labeling in different formats.

This study does have some weaknesses. First, we observe what customers order rather than what they consume, so while we can say that calories ordered decreases with calorie information for BYO sandwiches, we cannot say that calories consumed decreases. Second, because the data from this study were generated in a natural experiment, we do not have any individual-specific information, which prevents us from examining the effect of demographic or other individual-specific variables on calorie ordering. However, by not interacting directly with customers, we avoid customers changing their behavior because they are conscious of being evaluated or are responding to what they intuit the purpose of the study (Nichols and Maner, 2008). With addition of calorie information, customers in POST period may have been better able to guess at researchers' intentions had we interacted with them than customers in PRE period, which could have biased their responses. However, it would be of interest to be able to identify the mechanisms that lead to a decrease in calories ordered in BYO sandwiches, but not in DEF sandwiches. Future research in a controlled setting could examine these mechanisms more fully and provide an opportunity to examine whether there are any unintended consequences of per-ingredient calorie labeling. Further, we do not examine other important nutritional attributes—sodium, fat, fiber content—of the sandwiches because we are interested in how customers respond to information available to them when it is provided in different formats (per-ingredient versus per-sandwich). It is possible that substituting an ingredient that decreases calories ordered—selecting ham instead of turkey, for instance—will result in an increase in sodium ordered, another important dietary attribute. Finally, as this was a natural experiment in one location, we do not have a pure control group. However, the fact that we find no change in calories ordered with calorie information in the DEF sandwiches at the same time that we observe significant decreases in calories ordered in the BYO sandwiches suggests that customers are not simply becoming more health conscious.

Overall, we find strong evidence that the form of calorie labeling matters. Given that many individuals have strong, well-defined preferences for foods, per-ingredient calorie information provides an opportunity for consumers to substitute away from high-calorie items without fundamentally changing their choice in a way that the traditional means of providing calorie information do not (Schwartz et al., 2014). Per-ingredient calorie information may more effectively highlight trade-offs between taste and health by identifying the number of calories the consumer could save by forgoing an ingredient in their meal. Additionally, we find that the effect persists over time, suggesting that per-ingredient calorie information can effectively sustain reductions in calories ordered in important ingredients (Mochon et al., 2016) without engendering compensatory, indulgent substitutions in other categories.

Our study finds that the way in which calorie information is presented has a significant influence on how customers respond. The introduction of calorie information presented in the traditional format—the calorie amount for the full item—results in no change in calories ordered, but ingredient-specific calorie information yields a substantive and statistically significant decrease in calories per sandwich. Strategies to stem rising obesity rates frequently focus on giving consumers more nutrition information. Though the effects of these strategies have been modest, understanding how the information format influences decision-making could enhance the impact of these policies. Providing per-ingredient calorie information may help individuals identify high-calorie components of food items or meals that they would be willing to forgo.

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