Review
EPIDEMIOLOGY/GENETICS

Obesity

A Systematic Review of Calorie Labeling and Modified Calorie Labeling Interventions: Impact on Consumer and Restaurant Behavior

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Objective: Evidence on the effects of restaurant calorie labeling on consumer and restaurant behavior is mixed. This paper examined: (1) consumer responses to calorie information alone or compared to modified calorie information and (2) changes in restaurant offerings following or in advance of menu labeling implementation.

Methods: Searches were conducted in PubMed, Web of Science, Policy File, and PAIS International to identify restaurant calorie labeling studies through October 1, 2016, that measured calories ordered, consumed, or available for purchase on restaurant menus. The reference lists of calorie labeling articles were also searched.

Results: Fifty-three studies were included: 18 in real-world restaurants, 9 in cafeterias, and 21 in laboratory or simulation settings. Five examined restaurant offerings.

Conclusions: Because of a lack of well-powered studies with strong designs, the degree to which menu labeling encourages lower-calorie purchases and whether that translates to a healthier population are unclear. Although there is limited evidence that menu labeling affects calories purchased at fast-food restaurants, some evidence demonstrates that it lowers calories purchased at certain types of restaurants and in cafeteria settings. The limited data on modified calorie labels find that such labels can encourage lower-calorie purchases but may not differ in effects relative to calorie labels alone.

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Introduction

Obesity is associated with adverse health consequences (1-4) and substantial health care costs (5). Overconsumption of calories has been a key driver of rising obesity (6,7), and dining out is thought to play a significant role. Because people substantially underestimate the calories in prepared food (8), restaurant menu labeling was implemented in several cities and states (9,10) and is included in the 2010 Affordable Care Act (11,12). Chain restaurants, grocery stores, and other food retail establishments with 20 or more locations must post calorie information on their menus by May 2018 along with the statement "2,000 calories a day is used for general nutrition advice, but calorie needs vary." The hope is such information will encourage consumers to choose, and restaurants to offer, lower-calorie items.

This paper synthesizes the evidence on the effectiveness of menu labeling. Although we identified nine prior menu labeling reviews (13-21), we extend this research by reviewing the following: (1) newer studies; (2) research across restaurant, cafeteria, and laboratory settings; (3) studies comparing responses to calorie information (e.g., 400 calories) relative to modified calorie information or nutrition symbols (e.g., traffic light labels); and (4) studies of menu offerings following local menu labeling regulations and in advance of national regulations.

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Methods

We searched PubMed, Web of Science, Policy File, and PAIS International for all articles published through October 1, 2016, using a combination of the terms "restaurant," "cafeteria," "food service," "fast-food," "labeling," "calories," and "energy." (See Supporting Information for search details). We also examined reference lists of calorie labeling articles. After removing duplicate studies, one author (KV) screened titles and abstracts and reviewed the full text for inclusion. Another author (SB) confirmed inclusion of these studies, and a third author (CR) adjudicated differences. Included studies had to examine the effects of calorie information displayed on menus using calories offered, ordered, purchased, or consumed as an outcome. Studies of menu offerings included research conducted before and after local menu labeling regulations were implemented and in advance of national calorie labeling implementation. We did not examine the effect of labeling on intake of other nutrients, although some study menus displayed other nutrition information (e.g., sodium). We also included studies that compared calorie information to modified presentations of calorie information such as traffic light labels, total recommended daily calorie statements, and physical activity labels (presenting the amount of time one would have to exercise to burn off the calories eaten). We included studies conducted among adults, adolescents, and children. Studies were excluded for the following reasons: (1) did not report calories offered, ordered, purchased, or consumed as an outcome; (2) did not use restaurant-like menus or used menus with a small number of items (< 6 items) that may not generalize to typical restaurant settings; (3) only compared self-reported calorie label users to nonusers; (4) evaluated nutrition labels on packaged foods; (5) studied another intervention (e.g., price changes, educational sessions) in combination with calorie information such that the calorie label effect could not be isolated; or (6) tested whether participants changed menu orders after being asked to immediately reorder from the same menu containing calorie information.

Tables 1–4 present details of each study's design, methods, and outcomes based on setting. We summarize each study below based on setting (restaurant, cafeteria, or laboratory/simulation) and grouped by study design (e.g., randomized controlled trial [RCT]). Finally, we describe studies of changes in restaurant offerings after enacted or anticipated menu labeling regulations. Results reported as kilojoules have been converted to calories.

Results

Our search yielded 3,384 citations across four databases (see Supporting Information for PRISMA flow diagram). After removal of duplicates ($n = 568$), 2,816 titles and abstracts were screened and 2,737 were excluded. Following full-text review, 53 articles were included.

Real-world restaurant settings

Eighteen of forty-eight studies evaluated calorie information in real-world restaurant settings (Table 1). There was one RCT (22), one quasi-real-world RCT (23), seven natural experiments evaluating menu labeling before and after implementation and compared to control locations (24-30), seven studies evaluating labeling before and after implementation without a control comparison (31-37), and two using cross-sectional designs to compare labeled versus unlabeled locations (38,39). Three of these studies included children and/or adolescents (27,30,33).

RCTs. Ellison et al. (22) reported no difference in calories ordered after randomizing a sample of 138 customers of a full-service university campus restaurant to menus with either no calorie information, calorie labels, or calorie labels plus traffic lights, but the small cell size greatly limits the statistical power of the study.

In two quasi-real-world RCTs, Wisdom and colleagues (23) approached 638 customers entering a fast-food sandwich restaurant to complete a survey in exchange for a free meal. Using a $2 \times 2 \times 3$ design, participants were randomized to either a daily calorie recommendation statement or not, item calorie information or not, and conditions that made healthy sandwiches more or less convenient to order (healthy sandwiches were featured on an initial page and patrons had to open a sealed or unsealed menu to view the remaining sandwiches). The two studies only varied in the strength of the healthy sandwich convenience manipulation so were combined for analysis. Statistically significantly fewer calories were ordered in both the calorie label and daily calorie recommendation conditions compared to the no information group. The combination of both calorie labels and daily calorie recommendations led to a 100-calorie reduction.

Natural experiment with comparison site(s). The natural experiment with the strongest design and largest sample size was conducted by Bollinger et al. (24). They analyzed more than 100 million transactions before and after the implementation of the New York City (NYC) menu labeling law at multiple Starbucks locations, including control sites in Boston and Philadelphia. There was a statistically significant 6% decrease in mean calories per transaction (15 calories on average) in NYC locations driven by changes in food, not beverage, calories.

Another natural experiment with a large sample size and strong design was conducted by Finkelstein and colleagues (25). They saw no effect of menu labeling over 1 year when evaluating pre/post transaction data from seven locations of a Mexican fast-food chain in King County, Washington (labeled), compared to seven locations adjacent to King County (unlabeled).

Elbel et al. (26) reported no change in calories ordered based on 1,156 surveys of customers exiting fast-food restaurants in low-income neighborhoods of NYC (labeled) versus Newark, New Jersey (unlabeled), before and 4 weeks after labeling. Although they reported no decrease in calories ordered among children and adolescents ($n = 349$) (27), the small sample size (e.g., Newark $n = 49$ pre and $n = 34$ post labeling) makes it difficult to draw conclusions. A 5-year follow-up study in the same cities found no effect of labeling among adults at four fast-food restaurant chains (28). Elbel and colleagues also observed no decrease in calories ordered in a similar study in which they collected 2,083 surveys outside of McDonald's and Burger King locations in Philadelphia (labeled) compared to Baltimore (unlabeled) 2 months before and 4 months after labeling (29). Although these studies have strong designs, they were powered to detect only large effects of calorie labeling (i.e., the first NYC evaluation had 80% power to detect a 125-kcal reduction).

TABLE 1 Real-world restaurant studies of menu labeling

Author, year	Setting and sample size	Study design	Data collection methods	Outcome reported in this table	Mean calories purchased without labeling	Mean calories purchased during labeling intervention	Difference: (labeled − unlabeled)	Significance of effect and direction
Randomized controlled trial								
Ellison et al., 2013	138 customers at full-service restaurant on Oklahoma State University campus.	Randomized controlled field experiment. 3 conditions: (1) control; (2) calorie labels; (3) calorie labels plus traffic lights.	Collected sales data.	Unadjusted mean total calories ordered.	Control: 765 *Measures of variation not reported for this study*	Calorie labels: 817 Calories + traffic light labels: 696	+52[c] −69[c]	Null
Pre/post design with comparison site(s)								
Bollinger et al., 2011	All 222 Starbucks locations in NYC and all 94 Starbucks locations in Boston and Philadelphia (control sites). Over 100 million sales transactions.	Natural experiment. Difference-in-differences analysis. Cross-sectional data collection 3 months before and 11 months after calorie labeling law implemented in intervention and control cities.	Analyzed electronic sales transaction data from Starbucks locations. Collected in-store customer surveys in intervention (Seattle) and control cities.	Mean total calories per transaction.	247 *Measures of variation not reported for this study*	232	−15[a,c]	Significant reduction in calories
Cantor et al., 2015	7,699 adult customers in low-income, racial/ethnic minority communities in NYC, Newark, and Jersey City. 19 unique restaurant locations of 4 large fast-food chains (McDonald's, Burger King, Wendy's, KFC) surveyed in 2008 and 60 unique restaurant locations surveyed in 2013-2014.	Natural experiment. Difference-in-differences analysis. Cross-sectional data collection 4 weeks before calorie labeling law implemented and 4 weeks after as well as the following post-labeling time points: 4.5 years, 5 years, and 5.5 years.	Collected customer receipts and conducted surveys upon exiting restaurant. Participants in 2013-2014 also invited to participate in separate follow-up telephone survey.	Adjusted mean total calories purchased. Covariates: age, sex, race/ethnicity, restaurant chain, whether meal was to go or eat in.	Newark (control): 773 NYC (intervention): 796 *Measures of variation not reported for this study*	Newark post 4 wk: 756 Newark and Jersey City post 4.5 y: 845 Newark and Jersey City post 5 y: 802 Newark and Jersey City post 5.5 y: 857 NYC post 4 wk: 783 NYC + McDonald's post 4.5 y: 839 NYC + McDonald's post 5 y: 835 NYC + McDonald's post 5.5 y: 804	−17[c] +72[c] +29[c] +84[c] −13[c] +43[c] +39[c] +8[c]	Null

TABLE 1. (continued).

Author, year	Setting and sample size	Study design	Data collection methods	Outcome reported in this table	Mean calories purchased without labeling	Mean calories purchased during labeling intervention	Difference: (labeled – unlabeled)	Significance of effect and direction
Elbel et al., 2009	1,156 adult customers in low-income, racial/ethnic minority communities. 19 neighborhood-matched fast-food restaurants representing 4 large chains (McDonald's, Burger King, Wendy's, KFC). 14 restaurants in NYC (labeled), 5 in Newark (unlabeled).	Natural experiment. Difference-in-differences analysis. Cross-sectional data collection 4 weeks before and 4 weeks after calorie labeling law implemented in intervention and control city.	Collected customer receipts and conducted surveys upon exiting restaurant.	Adjusted mean total calories purchased. Covariates: age, sex, race/ethnicity, whether food was to go or eat in.	Newark (control): 823 [95% CI: 802-890] NYC (control): 825 [95% CI: 779-870]	Newark (control): 826 [95% CI: 746-906] NYC (intervention): 846 [95% CI: 758-889]	+3[c] +21[c]	Null
Elbel et al., 2011	349 children and adolescents in low-income, racial/ethnic minority communities in NYC and Newark. 19 neighborhood-matched fast-food restaurants representing 4 large chains (McDonald's, Burger King, Wendy's, KFC). 14 restaurants in NYC (labeled), 5 in Newark (unlabeled).	Natural experiment. Difference-in-differences analysis. Cross-sectional data collection 4 weeks before and 4 weeks after calorie labeling law implemented in intervention and control city.	Collected customer receipts and conducted surveys upon exiting restaurant.	Unadjusted mean total calories purchased by children in full sample.	Newark (control): 611 (SD: 366) NYC (intervention): 643 (SD: 334)	Newark (control): 673 (SD: 265) NYC (intervention): 652 (SD: 330)	+62[c] +9[c]	Null
Elbel et al., 2013	2,083 adult customers from 23 McDonald's and Burger King locations in Philadelphia (labeled) and Baltimore (unlabeled) before and after calorie labeling law implemented. Low-income participants oversampled.	Natural experiment. Difference-in-differences analysis. Cross-sectional data collection 2 months before and 4 months after calorie labeling law implemented in intervention and control city.	Collected customer receipts and conducted surveys upon exiting restaurant. Random-digit-dialing telephone interviews to assess self-reported exposure to menu labeling and restaurant visits.	Adjusted mean total calories purchased. Covariates: gender, age, race/ethnicity, education, restaurant chain, having overweight or obesity.	Baltimore (control): 992 Philadelphia (intervention): 959 *Measures of variation not reported for this study*	Baltimore (control): 940 Philadelphia (intervention): 904	−52[c] −55[c]	Null Null

TABLE 1. (continued).

Author, year	Setting and sample size	Study design	Data collection methods	Outcome reported in this table	Mean calories purchased without labeling	Mean calories purchased during labeling intervention	Difference: (labeled − unlabeled)	Significance of effect and direction
Finkelstein et al., 2011	14 Taco Time locations: seven in King County, WA (labeled) and seven in adjacent counties (unlabeled).	Natural experiment. Difference-in-differences analysis. Compared intervention and control cities before and after calorie labeling law implemented. 2 post-labeling time points included. Post-labeling time point 1: law in effect but drive-through menus not changed. Post-labeling time point 2: drive-through menus changed.	Collected total monthly restaurant sales transaction data between January 2008 and January 2010 (13 months after law implemented).	Unadjusted mean total calories per transaction.	Adjacent counties (control): 1,391 King County (intervention): 1,211 *Measures of variation not reported for this study*	Adjacent counties (control): Post 1: 1,392 Post 2: 1,376 King County (intervention): Post 1: 1,217 Post 2: 1,214	 $+1^{c}$ -15^{c} $+6^{c}$ $+3^{c}$	Null
Tandon et al., 2011	133 families with 6- to 11-year-old children in King County, WA ($n = 75$, labeled county) and San Diego County, CA ($n = 58$, control county).	Prospective cohort, collected data before and after implementation of calorie labeling in King County comparing intervention and control city.	Gave participants $10 gift card to fast-food restaurant. Collected mailed customer receipts after visits to restaurants; phone interviews.	Unadjusted mean total calories purchased for parents and children.	San Diego County (control) *Children*: 984 *Parents*: 895 King County (intervention) *Children*: 823 *Parents*: 823	San Diego County (control) *Children*: 949 *Parents*: 789 King County (intervention) *Children*: 822 *Parents*: 720	 -35^{c} -106^{c} -1^{c} -103^{c}	Null
Pre/post design without comparison site(s)								
Downs et al., 2013	1,094 adult customers at 2 McDonald's locations in NYC.	Cross-sectional data collection 2 months before and 2 months after calorie labeling law implemented. In addition, participants randomized to: given slip of paper with daily recommended calories OR meal recommended calories OR no slip given before entering McDonald's.	Collected customer receipts and conducted surveys upon exiting restaurant.	Adjusted mean total calories among group exposed to calorie labeling. Covariates: day of week, gender, race/ethnicity, age, location of restaurant.	Control: 812 (SE: 36) Per-meal calorie recommendation: 880 (SE: 34) Daily calorie recommendation: 865 (SE: 34)	Control: 833 (SE: 41) Per-meal calorie recommendation: 830 (SE: 38) Daily calorie recommendation: 897 (SE: 35)	$+21^{c}$ -50^{c} $+32^{c}$	Null

TABLE 1. (continued).

Author, year	Setting and sample size	Study design	Data collection methods	Outcome reported in this table	Mean calories purchased without labeling	Mean calories purchased during labeling intervention	Difference: (labeled − unlabeled)	Significance of effect and direction
Dumanovsky et al., 2011	7,309 adult customers in 2007 and 8,489 in 2009. 168 restaurant outlets of 11 fast-food chains in NYC.	Cross-sectional data collection 1 year before and 9 months after calorie labeling law.	Collected customer receipts and conducted surveys upon exiting restaurant.	Unadjusted mean total calories purchased.	2007 overall: 828 [95% CI: 807-849] McDonald's: 829 [95% CI: 803-836] Burger King: 924 [95% CI: 889-959] Wendy's: 858 [95% CI: 807-909] Subway: 749 [95% CI: 722-776] Au Bon Pain: 555 [95% CI: 513-596] KFC: 927 [95% CI: 896-957] Popeye's: 949 [95% CI: 884-1,013] Domino's: 1309 [95% CI: 979-1,640] Pizza Hut: 1039 [95% CI: 963-1,115] Papa John's: 623 [95% CI: 469-777] Taco Bell: 773 [95% CI: 670-876]	2009 overall: 846 [95% CI: 826-866] McDonald's: 785 [95% CI: 759-812] Burger King: 967 [95% CI: 928-1,007] Wendy's: 821 [95% CI: 771-871] Subway: 882 [95% CI: 860-905] Au Bon Pain: 475 [95% CI: 455-494] KFC: 868 [95% CI: 842-894] Popeye's: 975 [95% CI: 943-1,006] Domino's: 1029 [95% CI: 862-1,196] Pizza Hut: 943 [95% CI: 837-1,049] Papa John's: 571 [95% CI: 487-656] Taco Bell: 808 [95% CI: 765-851]	Overall: +18[c] McDonald's: −44[a,c] Burger King: +43[c] Wendy's: −37[c] Subway: +133[a,c] Au Bon Pain: −80[a,c] KFC: −59[a,c] Popeye's: +26[c] Domino's: −280[c] Pizza Hut: −96[c] Papa John's: −51[c] Taco Bell: +35[c]	Mixed
Holmes et al., 2013	Sit-down restaurant at private club in US town (population of 53,311 people). 1,275 kids' meal orders.	Longitudinal design with control and 3 types of menu labels, which were each introduced for 2 months. Labeling appeared only on combo meals (453 combos ordered out of 1,275 transactions).	Collected sales data.	Unadjusted mean total calories purchased in kids' meals.	Baseline (no label): 611 *Measures of variation not reported for this study*	Calorie and fat labeling: 601 Healthy symbol: 607 Nutrition bargain price: 605	−10[c] −4[c] −6[c]	Null

TABLE 1. (continued).

Author, year	Setting and sample size	Study design	Data collection methods	Outcome reported in this table	Mean calories purchased without labeling	Mean calories purchased during labeling intervention	Difference: (labeled − unlabeled)	Significance of effect and direction
Ge et al., 2014	Table service restaurant on campus of Purdue University.	Longitudinal design with control and 3 types of menus, each introduced for 1 week. Restaurant specials not included.	Analyzed lunch sales transaction data.	Unadjusted mean total calories purchased.	Control: 856 *Measures of variation not reported for this study*	Calories only: 730 Healthy symbol: 825 Nutrient list: 771	Calories only: −126[a,c] Healthy symbol: −31[c] Nutrient list: −85[c]	Significant reduction in calories
Krieger et al., 2013	7,325 customers ages ≥ 14 years. 40 fast-food and 10 coffee restaurants representing 10 restaurant chains in King County, WA.	Cross-sectional data collection before and after calorie labeling law. Collected data at 2 post-labeling time points: 4-6 months post and 16-18 months post.	Collected customer receipts and conducted surveys upon exiting restaurant.	Unadjusted mean total calories purchased.	Overall food chains: 909 [95% CI: 876-941] Burger chains: 905 [95% CI: 830-979] Sandwich chains: 872 [95% CI: 842-919] Taco chains: 980 [95% CI: 936-1,023] Coffee chains: 154 [95% CI: 43-166]	Food chains *Post 1*: 921 [95% CI: 888-954] *Post 2*: 870 [95% CI: 842-899] Burger chains *Post 1*: 895 [95% CI: 834-957] *Post 2*: 892 [95% CI: 831-953] Sandwich chains *Post 1*: 907 [95% CI: 866-947] *Post 2*: 862 [95% CI: 820-904] Taco chains *Post 1*: 971 [95% CI: 885-1,057] *Post 2*: 867 [95% CI: 816-918] Coffee chains *Post 1*: 144 [95% CI: 120-168] *Post 2*: 132 [95% CI: 117-147]	+13[c] −38[a,c] −9[c] −13[c] +35[c] −10[c] −9[c] −113[a,c] −11[c] −22.1[a,c]	Mixed

TABLE 1. (continued).

Author, year	Setting and sample size	Study design	Data collection methods	Outcome reported in this table	Mean calories purchased without labeling	Mean calories purchased during labeling intervention	Difference: (labeled − unlabeled)	Significance of effect and direction
Pulos et al., 2010	6 sit-down restaurants in Pierce County, WA. ∼16,000 entrees purchased.	Cross-sectional data collection 30 days before and 30 days after voluntary calorie labeling implemented.	Itemized historical restaurant sales data of entrée items only.	Adjusted mean total calories purchased. Covariates: entrée cost.	Not reported. *Measures of variation not reported for this study* (except for overall difference of means)	Not reported.	Overall: −15[a] [95% CI: −23 to −7][b] Restaurant 1: −16.8[a,c] Restaurant 2: −55.6[a,c] Restaurant 3: −53.6[a,c] Restaurant 4: −20.6[a,c] Restaurant 5: 12.1[c] Restaurant 6: −1.0[c]	Mixed
Schwartz et al., 2012 (Experiment 2)	399 customers at Chinese fast-food restaurant on the campus of Duke University and its adjacent Medical Center, Durham, NC.	Data collection before and after calorie labeling implemented on menu.	Collected restaurant sales transaction data.	Unadjusted mean total calories purchased.	Baseline (control): 1,020 *Measures of variation not reported for this study*	Calorie labeling: 1,033	+13[c]	Null
Cross-sectional comparing labeled vs. unlabeled sites								
Auchincloss et al., 2013	648 adult customers (327 at intervention site; 321 at control site). 7 outlets of 1 full-service chain restaurant; 2 outlets in Philadelphia with menu labeling, 5 outlets outside of Philadelphia with no labeling (control sites).	Cross-sectional, comparing intervention and control city.	Collected customer transaction receipts and conducted surveys upon exiting restaurant.	Unadjusted mean total calories ordered. Covariates: age, gender, race/ethnicity, income, education, day of week, frequency of dining out at sit-down restaurant, body size.	Control: 1,891 (SD: 785)	Philadelphia: 1,778 (SD: 824)	−155 [95% CI: −284 to −27][a,b]	Significant reduction in calories

TABLE 1. (continued).

Author, year	Setting and sample size	Study design	Data collection methods	Outcome reported in this table	Mean calories purchased without labeling	Mean calories purchased during labeling intervention	Difference: (labeled − unlabeled)	Significance of effect and direction
Rendell et al., 2014	245 adult customers from 2 Cosi chain restaurants in New Rochelle, NY (labeled) and Stamford, CT (unlabeled).	Cross-sectional, comparing intervention and control city.	Conducted surveys upon exiting.	Unadjusted mean total calories ordered.	Stamford (control): 743 (SD: 169)	New Rochelle (menu labeling): 705 (SD: 173)	-39^{c}	Null
Quasi-real-world intervention								
Wisdom et al., 2010	Real-world. 638 diners at 1 fast-food sandwich chain in Pittsburgh.	Randomized controlled field experiment. 2 separate studies conducted, but calorie labeling analysis combined because manipulation did not differ across studies. Factorial design: 2 calorie labeling conditions (label vs. no labeling) × 2 daily calorie recommendation information (yes/no) × 3 convenience manipulations (first page of menu had either most caloric, least caloric, or mixed sandwich options and consumers had choice to order from second menu if they wanted to see all options (study 1) or see all options on the next page (study 2).	Approached customers upon entering restaurant. Participants given menu based on factorial design. Asked to choose sandwich, side, and drink, then given coupon for that meal to redeem inside. Participants received free meal in exchange for completing the study.	Adjusted mean total calories purchased. Covariates: gender, age, race, study number, convenience manipulation.	Control: 851 (SE: 36)	Calorie labeling: 790 (SE: 19) Daily calorie recommendation: 813 (SE: 19) Calorie label and daily calorie recommendation: 752 (SE: Not reported)	-61^{a} -38^{a} -99^{a} N not reported for subgroups so cannot calculate CI for difference of means	Significant reduction in calories

$^{a}P < 0.05$.
[b]Author reported 95% confidence interval (CI) for difference in means.
[c]The study sample was nonindependent, and we lacked the information to calculate the CI.
Unadjusted means are reported unless paper only reported adjusted numbers. An absence of standard deviation (SD), standard error (SE), or CI indicates it was not reported in the paper.

TABLE 2 Real-world cafeteria studies of menu labeling

Author, year	Setting and sample size	Study design	Methods	Outcome reported in this table	Calories purchased: control group (unlabeled)	Calories purchased: intervention group (labeled)	Difference: (labeled − unlabeled)	Significance of effect and direction
Pre/post design without comparison site								
School/university cafeteria								
Chu et al., 2009	1 college dining hall at Ohio State University. Labeled 12 hot entrees with the following information: calories and serving size, fat, protein, and carbohydrates in grams.	Quasi-experimental, single group interrupted time series. 3 periods: (1) baseline (14 days); (2) nutrition labels (14 days); (3) post labels (13 days).	Dining hall electronically tracked sales data for the 12 labeled hot entrees.	Unadjusted mean entrée calories.	Pre labeling: 647 *Measures of variation not reported for this study*	Not reported	Difference: last day of baseline – first day of labeling $-12^{a,c}$	Significant reduction in calories
Hammond et al., 2015	159 university students ≥ 16 years of age. University cafeteria in southwestern Ontario, Canada.	Naturalistic cohort study. Data collected on same individuals before and after calorie labeling intervention.	Cafeteria patrons approached to complete exit survey at baseline and 6-week follow-up during lunch and dinner hours. Calories ordered and consumed based on self-reported items purchased and guided estimates of amount eaten.	Mean total calories ordered and consumed in a meal. *Note*: Mean calories unadjusted; difference in calories adjusted. Covariates: sex, BMI, race, perceived general health, weight perception, weight aspiration.	Pre labeling *Calories ordered*: 825 (SD: 336) *Calories consumed*: 769 (SD: 342)	Calorie labeling *Calories ordered*: 734 (SD: 331) *Calories consumed*: 671 (SD: 327)	$-91^{a,c}$ $-98^{a,c}$	Significant reduction in calories
Hunsberger et al., 2015	Average of 531 students per day aged 11 to 15 at rural, low-income middle school cafeteria In Madras, OR.	Gathered data 17 days pre calorie labeling and 17 days post calorie labeling. Conducted qualitative interviews with 32 students.	Gross calories served per student measured each day. Identical menu served on days with and without labels.	Unadjusted mean calories ordered per student.	Pre labeling: 668 [95% CI: 530-806]	Calorie labels: 621 [95% CI: 499-743]	$-47^{a,b}$ [95% CI: -77 to -18][b]	Significant reduction in calories
Lillico et al., 2015	299 female university students ≥ 16 years of age. University cafeteria in southwestern Ontario, Canada.	Naturalistic cohort study. Data collected on same individuals before and after calorie labeling intervention.	Cafeteria patrons were approached to complete exit survey at baseline and follow-up during lunch and dinner hours.	Mean total calories consumed *Note*: Mean calories unadjusted; difference in calories adjusted.	Pre labeling: 661 (SD: 309)	Calorie labels: 601 (SD: 282)	-60^{c}	Null

TABLE 2. (continued).

Author, year	Setting and sample size	Study design	Methods	Outcome reported in this table	Calories purchased: control group (unlabeled)	Calories purchased: intervention group (labeled)	Difference: (labeled − unlabeled)	Significance of effect and direction
			Calories ordered and consumed were based on self-reported items purchased and guided estimates of amount eaten.	Covariates: eating disturbance, BMI, race, perceived stress level, weight perceptions, weight aspirations.				
Milich et al., 1976	450 female employees. Workplace cafeteria at North Carolina Memorial Hospital, Chapel Hill, NC.	Cross-sectional data collection before and after calorie labeling intervention. 2 weeks of baseline, 1 week of price increase (5-10 cents on approximately half of the food items – cafeteria management did this, was not part of original study design and not intended to impact healthfulness of purchases), and 1 week of calorie labeling.	Recorded body size, every food item purchased (excluding sodas and condiments), and total price indicated on cash register every Monday, Wednesday, and Friday.	Unadjusted mean total calories purchased, excluding sodas condiments.	Pre labeling: 507 Unexpected price increase (no labels): 525 *Measures of variation not reported for this study*	Calorie labels: 459 459	 −48[c] −66[a,c]	Significant reduction in calories
Nikolaou et al., 2014	120 university students. University cafeteria at University of Glasgow, Scotland.	Interrupted time-series design. Year 1: no calorie labels. Year 2: calorie labels.	Observed and recorded all items on the trays of first 100 meals selected during 14 days identified as having choices with wide calorie range during each labeling period. Assessed self-reported mean weight changes (validated with sub-sample of objective weights).	Unadjusted mean calories ordered.	Pre labeling *Females*: 709 (SD: 101) *Males*: 734 (SD: 101)	Calorie labels *Females*: 628 (SD: 105) *Males*: 692 (SD: 105) Calorie label + daily caloric recommendation *Females*: 534 (SD: 116) *Males*: 622 (SD: 116)	 −81[a,c] −42[a,c] −175[a,c] −112[a,c]	Significant reduction in calories

TABLE 2. (continued).

Author, year	Setting and sample size	Study design	Methods	Outcome reported in this table	Calories purchased: control group (unlabeled)	Calories purchased: intervention group (labeled)	Difference: (labeled − unlabeled)	Significance of effect and direction
Workplace cafeteria								
Schmitz and Fielding, 1986	2,000 employees dining on-site. Company located in southern California.	Cross-sectional data collection before and after calorie labeling intervention.	Research assistant recorded every 10th customer's purchase for 2 weeks pre and post calorie labeling.	Mean total calories purchased per tray.	Control: 638 (SD: 400)	Calorie labeling: 567 (SD: 353)	−71[a,c]	Significant reduction in calories
Ussher et al., 2015	2,004 staff and visitors dining at hospital cafeteria in Ireland	Cross-sectional data collection before and after calorie labeling intervention.	Observed calories purchased during breakfast and lunch meals for 5 days pre labeling and 6 weeks post labeling.	Mean total calories purchased per meal.	Males *Breakfast*: 598 *Lunch*: 813 *Both*: 668 Females *Breakfast*: 419 *Lunch*: 635 *Both*: 530	*Males* *Breakfast*: 585 *Lunch*: 622 *Both*: 612 *Females* *Breakfast*: 406 *Lunch*: 551 *Both*: 496	Males *Breakfast*: −13[c] *Lunch*: −191[a,c] *Both*: −56[a,c] Females *Breakfast*: −13[c] *Lunch*: −84[a,c] *Both*: −34[c]	Significant reduction in calories
Quasi-real-world intervention								
VanEpps et al., 2015	249 corporate employees dining at on-site cafeteria placed lunch orders on newly launched website. Company location in Louisville, KY.	Randomized, controlled field experiment. 4 conditions: (1) no labels; (2) calorie labels; (3) traffic light labels; (4) calorie labels plus traffic lights.	Participants ordered lunches to be picked up from on-site corporate cafeteria via website over 4-week study period.	Mean total calories ordered per meal. Covariates: multiple orders by individual participants.	Control: 601 (SE: 18)	Calorie labeling: 538 (SE: 31) Traffic light labeling: 532 (SE: 33) Calorie + traffic light labeling: 528 (SE: 33)	−63 [95% CI: −124 to −2][a] −69 [95% CI: −134 to −5][a] −73 [95% CI: −139 to −6][a]	Significant reduction in calories

[a]$P < 0.05$.
[b]Author reported 95% confidence interval (CI) for difference in means.
[c]The study sample was nonindependent and we lacked the information to calculate the CI.
Unadjusted means are reported unless paper only reported adjusted numbers. An absence of standard deviation (SD), standard error (SE), or CI indicates it was not reported in the paper.

TABLE 3 Laboratory or simulation studies of menu labeling

Author, year	Setting and sample size	Study design	Methods	Outcome reported in this table	Calories purchased: control group (unlabeled)	Calories purchased: intervention group (labeled)	Difference: (labeled − unlabeled)	Significance of effect and direction
Laboratory, actual food selection and consumption								
Hammond et al., 2013	Laboratory. 635 Canadian adults 18 years of age or older.	Randomized controlled experiment. 4 conditions: (1) no information; (2) calorie information; (3) calories plus traffic lights with high/med/low text; (4) calorie, sodium, fat, and sugar content plus multiple traffic lights with high/med/low text.	Participants ordered free meal from Subway menu. Food intake measured by weighing food.	Mean calories ordered. Mean calories consumed. *Note*: Mean calories and differences for calories ordered unadjusted; difference in calories Calories consumed adjusted. Covariates: age, sex, education, ethnicity, BMI.	Control *Calories ordered*: 903 (SD: 319) *Calories consumed*: 840 (SD: 319)	Calorie label *Calories ordered*: 851 (SD: 366) *Calories consumed*: 744 (SD: 368) Calories + traffic light labeling *Calories ordered*: 857 (SD: 366) *Calories consumed*: 777 (SD: 351) Multiple traffic light labeling *Calories ordered*: 856 (SD: 345) *Calories consumed*: 765 (SD: 326)	−52 [95% CI: −127 to 23] −96 [95% CI: −171 to −21][a] −46 [95% CI: −122 to 30] −63 [95% CI: −137 to 11] −47 [95% CI: −121 to 27] −75 [95% CI: −147 to −3]	Significant reduction in calories
Harnack et al., 2008	Laboratory. 594 adults and adolescents 16 or older in Minneapolis and St. Paul, MN.	Randomized controlled experiment. 4 conditions: (1) standard menu; (2) calorie labels; (3) value size pricing; (4) calorie labels plus value size pricing. Menus with calorie labels also included information about daily recommended caloric intake.	Participants ordered meals from McDonald's menus. They were initially told they would pay for their meals but ultimately did not. Food intake measured by weighing food.	Unadjusted mean total calories ordered.	Control: 828 (SD: 401)	Calorie label + daily recommendation: 874 (SD: 439) Value pricing: 882 (SD: 354) Calorie label + daily recommendation + value pricing: 842 (SD: 425)	+46 [95% CI: −49 to 141] +54 [95% CI: −33 to 141] +14 [95% CI: −80 to 108]	Null
James et al., 2014	Laboratory. 300 participants from Texas Christian University, ages 18-30.	Randomized controlled experiment. 3 conditions: (1) control; (2) calorie labels; (3) exercise equivalent (minutes of brisk walking) labels.	Participants ordered from menus. Food intake measured by weighing food.	Adjusted mean total calories ordered. Adjusted mean total calories consumed. Covariates: premeal hunger level, sex.	Control *Calories ordered*: 902 [95% CI: 840-963] *Calories consumed*: 770 [95% CI: 717-823]	Calorie label *Calories ordered*: 827 [95% CI: 766-888] *Calories consumed*: 722 [95% CI: 669-776] Exercise label *Calories ordered*: 763 [95% CI: 703-824] *Calories consumed*: 673 [95% CI: 620-725]	−75 [95% CI: −84 to −66] −48 [95% CI: −56 to −40] −139 [95% CI: −148 to −130][a] −97 [95% CI: −104 to −90]	Mixed

TABLE 3. (continued).

Author, year	Setting and sample size	Study design	Methods	Outcome reported in this table	Calories purchased: control group (unlabeled)	Calories purchased: intervention group (labeled)	Difference: (labeled − unlabeled)	Significance of effect and direction
Platkin et al., 2014	Laboratory. 62 females with overweight or obesity, ages 18-34, recruited at public university in southern Florida.	Randomized controlled experiment with repeated measures. In the follow-up, participants randomized to 1 of 3 conditions: (1) no calorie information; (2) calorie labels; (3) calorie labels and exercise equivalents.	In week 1, participants ordered lunch from Burger King menu. At week 2 lunch, participants randomized to 1 of the label conditions and ordered second lunch. Amount of food eaten was weighed.	Adjusted mean calories ordered and consumed. Covariates: age, BMI, race, dietary restraint.	Control *Lunch 1 calories ordered*: 1,201 (SE: 100) *Lunch 1 calories consumed*: 987 (SE: 84) Calorie labels (but no label on menu for this order) *Lunch 1 calories ordered*: 1,283 (SE: 90) *Lunch 1 calories consumed*: 1,060 (SE: 73) Calorie labels + exercise equivalent labels (but no label on menu for this order) *Lunch 1 calories ordered*: 1,163 (SE: 141) *Lunch 1 calories consumed*: 841 (SE: 89)	Control *Lunch 2 calories ordered*: 1,176 (SE: 100) *Lunch 2 calories consumed*: 995 (SE: 92) Calorie labels *Lunch 2 calories ordered*: 1,077 (SE: 114) *Lunch 2 calories consumed*: 899 (SE: 88) Calorie labels + exercise equivalent labels *Lunch 2 calories ordered*: 1,001 (SE: 98) *Lunch 2 calories consumed*: 841 (SE: 82)	−25 [95% CI: −228 to 178] +9 [95% CI: −170 to 188] −206 [95% CI: −427 to 30] −161 [95% CI: −388 to 66] −162 [95% CI: −444 to 120] 0 [95% CI: −164 to 164]	Null
Roberto et al., 2010	Laboratory. 287 adults in New Haven, CT.	Randomized controlled experiment. 3 conditions: (1) control; (2) calorie labels; or (3) calorie labels + daily intake recommendation.	Participants ordered from full-service restaurant menu and food intake measured by weighing food. Participants returned the next day to complete 24-hour dietary recall interview.	Unadjusted mean calories ordered and consumed.	Control *Calories ordered*: 2,189 (SD: 1,081) *Calories consumed*: 1,459 (SD: 725) *Self-reported calories consumed after dinner*: 179 (SD: 310) *Calories consumed at dinner + after dinner*: 1,630 (SD: 811)	Calorie labeling *Calories ordered*: 1,862 (SD: 937) *Calories consumed*: 1,335 (SD: 621) *Self-reported calories consumed after dinner*: 293 (SD: 387) *Calories consumed at dinner + after dinner*: 1,625 (SD: 741) Calorie labeling + daily intake recommendation *Calories ordered*: 1,860 (SD: 1,063) *Calories consumed*: 1,256 (SD: 688)	−327 [95% CI: −617 to −37][a] −124 [95% CI: −318 to 70] (only significant when 2 calorie label groups combined and compared to control) +114 [95% CI: 13-215][a] −5 [95% CI: −228 to 218] −329 [95% CI: −630 to −28][a] −203 [95% CI: −402 to −4]	Significant reduction in calories

TABLE 3. (continued).

Author, year	Setting and sample size	Study design	Methods	Outcome reported in this table	Calories purchased: control group (unlabeled)	Calories purchased: intervention group (labeled)	Difference: (labeled − unlabeled)	Significance of effect and direction
						Self-reported calories consumed after dinner: 177 (SD: 309) *Calories consumed at dinner + after dinner*: 1,380 (639)	(only significant when 2 calorie label groups combined and compared to control) −2 [95% CI: −89 to 85] −250 [95% CI: −456 to −44][a]	
Laboratory, hypothetical food selection								
Gerend et al., 2009	Laboratory. 288 college students from introductory psychology course, Florida State University.	Randomized controlled experiment. 2 × 3 design. 2 label conditions: (1) no labels; (2) calorie labels. 3 dinner scenarios: "quick dinner," "starving," and "not too hungry."	Participants made hypothetical choices from 1 of 2 McDonald's menus, under 1 of 3 dinner scenarios.	Unadjusted mean calories per meal (all scenarios averaged together)	Control *Women*: 934 (SD: 371) *Men*: 1,052 (SD: 313)	Calorie label *Women*: 788 (SD: 274) *Men*: 1,144 (SD: 362)	−146[a] +92 *Subgroup sample size not reported so could not calculate CI of difference*	Mixed
Lee et al., 2016	Laboratory 643 undergraduate students from large southeastern state university's online participant pool.	Randomized controlled experiment. (1) no labels; (2) calorie labels; (3) calorie labels, plus miles; (4) control.	Participants made hypothetical choices from fast-food menu using online survey platform.	Unadjusted mean calories ordered.	Control: 1,041 (SD: 521)	Calorie labels: 1,022 (SD: 548) Calorie labels, plus miles: 1,046 (SD: 626)	−19 [95% CI: −122 to 84] +5 [95% CI: −103 to 113]	Null
Reale and Flint, 2016	Laboratory. 61 people with obesity from weight management service.	Randomized crossover design. (1) calories only; (2) nutrient content; (3) energy expenditure; (4) control (always received first).	Participants ordered from physical menu for hypothetical evening meal.	Unadjusted mean total calories ordered.	Control: 919 (SD: 416)	Calorie labels: 601 (SD: 254)[a]	−318[a]	Significant reduction in calories
Stutts et al., 2011	Laboratory. 236 children ages 6-11, recruited through Girl Scouts and Boy Scouts in the US.	Randomized controlled experiment. Factorial design: 3 label conditions (calorie and fat content, heart symbol or no information) × 2 gender × 2 age (6-8 or 9-11)	Children made hypothetical food choices from 2 menu boards with items from McDonald's and Wendy's.	Adjusted mean total calories ordered. Covariates: gender, age, ethnicity, weekly fast-food frequency, weight category, daily television viewing, parent's perception of child's weight category, socioeconomic status,	Control *Wendy's menu*: 447 (SD: 416) *McDonald's menu*: 527 (SD: 377)	Calories and fat label *Wendy's menu*: 522 (SD: 393) *McDonald's menu*: 540 (SD: 356) Heart Symbol *Wendy's menu*: 416 (SD: 420)	Calories and fat label *Wendy's*: +75 [95% CI: −52 to 202] *McDonald's*: +13 [95% CI: −102 to 128] Heart symbol *Wendy's*: −31 [95% CI: −163 to 101]	Mixed

TABLE 3. (continued).

Author, year	Setting and sample size	Study design	Methods	Outcome reported in this table	Calories purchased: control group (unlabeled)	Calories purchased: intervention group (labeled)	Difference: (labeled − unlabeled)	Significance of effect and direction
				frequency parent talks to child about eating, strictness, attentiveness, child's nutrition knowledge.		*McDonald's menu*: 369 (SD: 380)	*McDonald's*: −158 [95% CI: −278 to −38][a]	
Wei et al, 2013	Laboratory. 178 participants from Midwestern town in Indiana, recruited from community e-newsletter.	Randomized controlled experiment. 2×2 factorial design with calorie information (yes/no) and restaurant type (healthful vs. unhealthful).	Participants made hypothetical menu choices from menu boards.	Mean total calories ordered.	Control *Healthful restaurant*: 715 (SD: 313) *Unhealthful restaurant*: 612 (SD: 234)	Calorie labeling *Healthful restaurant*: 619 (SD: 254) *Unhealthful restaurant*: 668 (SD: 276)	No significant overall effect of menu labeling −96[a] +56 *Subgroup sample size not reported so could not calculate CI of difference*	Mixed
Simulation, hypothetical food selection								
Antonelli et al., 2015	Online simulation. 823 parents from US survey.	Randomized controlled experiment. 4 conditions: (1) calorie labels; (2) calorie + minutes to walk labels; (3) calories + miles to walk labels.	Online participants ordered food from hypothetical fast-food menu and completed survey.	Unadjusted median total calories ordered by parents for themselves.	Control: 1,580 *Measures of variation not reported for this study*	Calorie label: 1,200 Calorie + minutes to walk label: 1,140 Calorie + miles to walk label: 1,210	Calorie label: −380[a] Calorie + minutes to walk label: −440[a] Calorie + miles to walk label: −370[a]	Significant reduction in calories
Dodds et al., 2014	Telephone simulation. 329 Australian parents with a child between 3 and 12 years of age randomly sampled from larger household cohort study.	Randomized controlled experiment. 3 conditions: (1) standard menu; (2) menu with kilojoule labels + a statement indicating the daily energy intake for adults; (3) menu with traffic light labels.	Participants mailed 1 of the 3 menus and then completed telephone interview where they selected hypothetical meal for themselves and hypothetical meal for their child.	Unadjusted mean total energy of meals selected for parents and children (kilojoules converted to calories).	Control *Parents*: 509 (SD: 257) *Parents for child*: 630 (SD: 205)	Kilojoule labeling *Parents*: 521 (SD: 288) *Parents for child*: 616 (SD: 168) Traffic light label *Parents*: 458 (SD: 277) *Parents for child*: 625 (SD: 211)	+12 [95% CI: −61 to 86] −14 [95% CI: −64 to 36] −51 [95% CI: −121 to 20] −5 [95% CI: −60 to 49]	Null
Downs et al. 2015	Street simulation in shopping and recreation street in Pittsburgh. 921 participants.	Randomized controlled experiment. 10 conditions, categorized into: (1) control; (2) basic numeric information; (3) contextualized information;	Participants recruited from high-traffic pedestrian downtown street corner and made choices from menu.	Adjusted mean total calories of snack chosen Covariates: demographics.	Control: 222 (SD: 117)	Calorie labels: 200 (SD: 112) Basic information: 206 (SD: 112) Contextualized information: 198 (SD: 118) Heuristic cues: 192 (SD: 118)	Calorie labels: −22 [95% CI: −47 to 3] Basic information: −16 [95% CI: −3 to 5] Contextualized information: −24 [95% CI: −47 to −1][a] Heuristic cues: −30 [95% CI: −53 to −7][a]	Mixed

TABLE 3. (continued).

Author, year	Setting and sample size	Study design	Methods	Outcome reported in this table	Calories purchased: control group (unlabeled)	Calories purchased: intervention group (labeled)	Difference: (labeled – unlabeled)	Significance of effect and direction
		(4) heuristic cues. The latter 3 groups each had 3 subtechniques.						
Dowray et al., 2013	Online simulation. 802 employees from university system in North Carolina.	Randomized controlled experiment. 3 conditions: (1) calorie labels; (2) calorie + minutes walking labels; (3) calorie + miles walking labels.	Online participants ordered from hypothetical fast-food menu and completed survey.	Unadjusted mean total calories ordered.	Control: 1,020 (SD: 579)	Calorie label: 927 (SD: 682) Calorie + minutes walking label: 916 (SD: 664) Calorie + miles walking label: 826 (SD: 539)	−93 [95% CI: −217 to 31] −104 [95% CI: −226 to 18] −194 [95% CI: −305 to −83][a]	Mixed
Haws and Liu, 2016	Online simulation. 245 adults in the US	Randomized controlled experiment. 2×2 design. Randomized to: calorie labels (present vs. absent) or pricing (linear vs. quantity discounted such that price per unit of product was lower for larger portion sizes).	Online participants placed hypothetical dinner orders from menu with 10 entrée choices. Each item had full or half size option.	Adjusted mean total calories ordered. Covariates: gender.	No calories + linear pricing: 976 No calories + nonlinear pricing: 891 *Measures of variation not reported for this study*	Calorie label + linear pricing: 801 Calorie label + nonlinear pricing: 866	Significant main effect of calorie information on calories ordered[a] −175[a] −25	Significant reduction in calories
Liu et al., 2012	Online simulation. 419 US participants recruited from online database.	Randomized controlled experiment. 4 conditions: (1) control; (2) calorie labels + daily recommended intake statement; (3) calorie labels ranked from low to high calories + daily recommended intake statement; (4) calorie labels ranked from low to high calories + daily	Participants ordered from hypothetical menu adapted from Chili's and Applebee's.	Unadjusted mean total calories ordered. Differences reported here are unadjusted, but statistical analyses conducted controlling for frequency of nutrition label use, presurvey hunger, and gender.	Control: 1,760 (SE: 195)	Calories + daily intake statement: 1,676 (SE: 133) Rank-ordered calories+daily intake statement: 1,606 (SE: 146) Rank-ordered calories with green or red circles+daily intake statement: 1,455 (SE: 86)	−84 [95% CI: −549 to 381] −154 [95% CI: −635 to 327][a] (significant with covariates only) − 305 [95% CI: −726 to 116]	Mixed

TABLE 3. (continued).

Author, year	Setting and sample size	Study design	Methods	Outcome reported in this table	Calories purchased: control group (unlabeled)	Calories purchased: intervention group (labeled)	Difference: (labeled − unlabeled)	Significance of effect and direction
		recommended intake statement + green or red circles.						
Morley et al., 2013	Online simulation. 1,294 adults ages 18-49 in Victoria, Australia, who had purchased fast-food in the last month.	Randomized controlled experiment. 5 conditions: (1) control; (2) kilojoules (kJ) labels; (3) kJ + % daily intake labels; (4) kJ + traffic light labels; (5) kJ + traffic light + % daily intake labels.	Online participants ordered dinner from hypothetical fast-food menu. Menu restricted to 3 items from mains and sides, 2 items from drinks and desserts.	Unadjusted mean total energy content of meal selection (reported here in calories, reported as kilojoules in original paper).	Control: 1,105 *Measures of variation not reported for this study*	kJ (calorie) label: 988 kJ (calorie) + % daily intake label: 1,014 kJ (calorie) + traffic light label: 986 kJ (calorie) + traffic light + % daily intake label: 1,082	−117[a] −91 −119[a] −23	Significant reduction in calories
Pang and Hammond, 2013	Laboratory simulation. 213 undergraduate university students from University of Waterloo, Canada, recruited from 4 health-related classes. Students had to be > 18 years of age.	Randomized controlled experiment. 4 conditions: (1) no calorie information; (2) calorie labels; (3) calorie + health statement; (4) calorie + exercise equivalent statement.	Participants selected hypothetical snack from Tim Horton's menu.	Adjusted mean calories ordered. Covariates: age, gender, perceived importance of healthy diet.	Control: 333 (CI: 283-383)	Calorie labeling: 302 (CI: 243-361) Calorie labeling + recommended daily caloric intake statement: 298 (CI: 234-361) Calorie labeling + exercise equivalent statement: 310 (CI: 251-369)	−31 [95% CI: −107 to 45][a] −35 [95% CI: −115 to 45][a] −23 [95% CI: −100 to 53]	Significant reduction in calories
Roseman et al., 2013	Street simulation in medium-sized US city. 302 adult participants	Randomized controlled experiment. 2 conditions: (1) no labels; (2) calorie labels.	Participants recruited from high-traffic pedestrian downtown street corner and made hypothetical choices from menu.	Unadjusted mean calories ordered	Control: Not reported Report looking at nutrition labels when grocery shopping: 714 (SD: 188)	Calorie labeling: Not reported Report looking at nutrition labels when grocery shopping: 687 (SD: 170)	No significant overall effect of menu labeling −27[a]	Null

TABLE 3. (continued).

Author, year	Setting and sample size	Study design	Methods	Outcome reported in this table	Calories purchased: control group (unlabeled)	Calories purchased: intervention group (labeled)	Difference: (labeled – unlabeled)	Significance of effect and direction
					Report not looking at nutrition labels when grocery shopping: 737 (SD: 220)	Report not looking at nutrition labels when grocery shopping: 831 (SD: 205)	+94[a] *Subgroup sample size not reported so could not calculate CI of difference*	
Tandon et al., 2010	Clinic in Seattle, WA. 99 families recruited from pediatric clinic.	Randomized controlled experiment. 2 conditions: (1) no labels; (2) calorie labels.	Parents made hypothetical choices for themselves and their child from McDonald's menu.	Unadjusted mean total calories ordered for child and for self.	Control *Calories ordered for child*: 672 (SD: 264) *Calories ordered for parent*: 759 (SD: 524)	Calorie label *Calories ordered for child*: 569 (SD: 208) *Calories ordered for parent*: 766 (SD: 386)	−103 [95% CI: −198 to −8][a] +7 [95% CI: −178 to 192]	Significant reduction in calories
Viera et al., 2015	Online simulation. 823 parents from US survey.	Randomized controlled experiment. 4 conditions: (1) calorie labels; (2) calories + minutes to walk labels; (3) calories + miles to walk labels.	Online participants ordered food for their children from hypothetical fast-food menu and completed survey.	Unadjusted mean total calories ordered by parents for children.	Control: 1,294 *Measures of variation not reported for this study*	Calorie label: 1,066 Calorie + minutes to walk label: 1,060 Calorie + miles to walk label: 1,099	−228[a] −234[a] −195[a]	Significant reduction in calories

[a]$P < 0.05$.
Unadjusted means are reported unless paper only reported adjusted numbers. An absence of standard deviation (SD), standard error (SE), or confidence interval (CI) indicates it was not reported in the paper.

TABLE 4 Restaurant reformulation studies

Author, year	Setting and sample size	Study design	Methods	Outcome reported in this table	Calories purchased: control group (unlabeled)	Calories purchased: intervention group (labeled)	Difference: (labeled − unlabeled)	Significance of effect and direction
Pre/post design with comparison site								
Namba et al., 2013	9 restaurants in 2005 and in 2011 after labeling law went into effect. 5 restaurants were in areas subject to labeling laws (case) and 4 were not (control).	Menus from 5 fast-food chains (labeled) compared with menus from 4 food chains (not labeled) in 2005 and in 2011.	Conducted trend analysis to assess whether restaurants subject to labeling laws improved the healthfulness of their menus relative to the restaurants not subject to the labeling law.	Mean calories of menu items at labeled restaurants. Mean calories of menu items at nonlabeled restaurants.	Labeled 2005 *Entrees*: 419 (SD: 192) *Sides*: 288 (SD: 140) Nonlabeled 2005 *Entrees*: 474 (SD: 190) *Sides*: 302 (SD: 139)	Labeled 2011 *Entrees*: 422 (SD: 186) *Sides*: 264 (SD: 143) Nonlabeled 2011 *Entrees*: 481 (SD: 199) *Sides*: 287 (SD: 146)	 +3[b] −24[b] +7[2] −15[b]	Null
Restaurant trends in presence of menu labeling, without comparison site								
Bruemmer et al., 2012	37 chain restaurants (including sit-down and quick-service) of 92 labeled chains in King County, WA. Analyzed 3,941 menu items, including 2,300 entrees.	Examined menu items 6 months and 18 months after implementation.	Audited menus at restaurants 6 months and 18 months postimplementation.	Mean entrée item calories at all restaurant types (sit-down + quick-service) Mean entrée item calories at sit-down restaurants. Mean entrée item calories at quick-service restaurants.	6 months post: 818 (SD: 407) *Sit down*: 1,044 (SD: 438) *Quick service*: 668 (SD: 304)	18 months post: 777 (SD: 388) *Sit down*: 970 (SD: 425) *Quick service*: 650 (SD: 300)	−41 (SD: 156)[a,b] −73 (SD: 217)[a,b] −19 (SD: 91)[a,b]	Significant reduction in calories
Restaurant trends in advance of national menu labeling								
Bleich et al., 2015	66 chain restaurants from nationwide database. Analyzed 23,066 menu items.	Compared menu items from 2012, 2013, and 2014.	Used MenuStat to obtain calorie information from menu items in 2012-2014.	Mean calories for all menu items, Mean calories in newly introduced items	Year 2012: 345 470	Year 2013: 345 Year 2014: 349 Year 2013: 399 Year 2014: 401	0[b] +4[b] −71[a,b] −69[a,b]	Null
Bleich et al., 2016	66 chain restaurants from nationwide database, 5 of which voluntarily posted calorie labels. Analyzed 23,066 menu items, 3,675 of which were sold by the 5 voluntary-label restaurant chains.	Compared menu items from restaurants with voluntary menu labeling vs. without voluntary menu labeling.	Used MenuStat to obtain calorie information from menu items in 2012-2014.	Mean calories for all menu items. Mean calories in new items for that year.	No voluntary menu labeling *Year 2012*: 399 *Year 2013*: 398 *Year 2014*: 403 *Year 2012*: 519 *Year 2013*: 445 *Year 2014*: 419	With voluntary menu labeling *Year 2012*: 260 *Year 2013*: 262 *Year 2014*: 263 *Year 2012*: 232 *Year 2013*: 263 *Year 2014*: 309	 −139[a,b] −136[a,b] −140[a,b] −286[a,b] −182[a,b] −110[a,b]	Significant reduction in calories

TABLE 4. (continued).

Author, year	Setting and sample size	Study design	Methods	Outcome reported in this table	Calories purchased: control group (unlabeled)	Calories purchased: intervention group (labeled)	Difference: (labeled – unlabeled)	Significance of effect and direction
Wu and Sturm, 2014	213 chain restaurant brands, including 109 with children's menu data. Analyzed 26,256 (12,843 at baseline, 13,413 at follow-up) adult entrees and 1,794 (859 at baseline, 935 at follow-up) children's menu entrees.	Examined menu items before and after passage of Affordable Care Act (calorie posting only implemented in a few locations).	Analyzed nutrient content of menu items based on information available on restaurant websites.	Unadjusted mean entrée item calories in regular menu items at all restaurant types.	Year 2010: 670 (SD: 398)	Year 2011: 670 (SD: 397)	0^{b}	Null
				Unadjusted mean entrée item calories in children's menu items at all restaurant types.	462 (SD: 214)	468 (SD: 219)	$+6^{b}$	
				Adjusted mean entrée item calories in children's menu items at fast-food restaurants	Not reported	Not reported	$-40^{a,b}$	
				Adjusted mean entrée item calories in children's menu items at upscale restaurants.	Not reported	Not reported	$+46^{a,b}$	

[a] $P < 0.05$.
[b] The study sample was nonindependent and we lacked the information to calculate the confidence intervals (CI).
Unadjusted means are reported unless paper only reported adjusted numbers. An absence of standard deviation (SD), standard error (SE), or CI indicates it was not reported in the paper.

Using a strong longitudinal design, but limited by a small sample size, Tandon and colleagues (30) observed no differences in calories ordered among a sample of 75 parent-child pairs in King County, Washington (labeled) compared to 58 parent-child pairs in San Diego County (unlabeled).

Pre/post design without comparison site(s). Downs et al. (31) collected data before and after menu labeling implementation in NYC (no control city). In addition, they randomly assigned 1,094 adults entering two McDonald's locations to receive a paper slip with either recommended daily calories or per meal calories (for women and men) or no recommendation. Neither calorie labeling nor the addition of the recommendation messages had a statistically significant impact on calories purchased.

Dumanovsky et al. (32) gathered receipts from 7,309 fast-food patrons prior to calorie labeling and 8,489 patrons after calorie labeling across 11 fast-food chains at 168 locations in NYC. There was no overall effect of labeling, but statistically significant declines in calories purchased occurred at McDonald's, Au Bon Pain, and KFC, while calories ordered at Subway increased.

Holmes et al. (33) circulated menus for 2 months each at a full-service restaurant in a private club that either had (1) no calorie information, (2) calorie and fat information, (3) an apple symbol added to three combos to denote "healthier" choices, or (4) nutrition bargain prices (the monetary price divided by a nutrition scaling factor). Based on sales data, there was no association between label condition and calories ordered for 1,257 children's meals.

Schwartz et al. (34) analyzed transaction data for 399 customers eating at a Chinese quick-service chain over several weeks. The primary goal of the study was to evaluate a portion downsizing intervention, but calorie labels were introduced during a data collection period. Labels were not associated with decreases in calories ordered or eaten.

Ge and colleagues (35) analyzed lunchtime sales data at a table-service restaurant in Indiana. Each of the following interventions were delivered for 1 week: (1) control, (2) calorie information, (3) healthy symbol, and (4) calorie, fat, cholesterol, sodium, and fiber information, alongside daily recommended values. Compared to the control week, calorie labels resulted in a statistically significant decrease in calories purchased. Krieger et al. (36) collected receipts from 7,325 customers $\geq$ 14 years old before and after menu labeling implementation at 50 locations of 10 chain restaurants in King County, Washington. At 18 months after labeling implementation, there was a nonstatistically significant mean reduction of 38 calories in all food chains (not including coffee chains) and a statistically significant decrease in calories purchased at taco restaurants and coffee chains.

Pulos and Leng (37) conducted a pre/post analysis at six full-service restaurants in Pierce County, Washington, 30 days before and after displaying information on calories, fat, sodium, and carbohydrates. Beverages, certain side items, and daily specials were unlabeled. An analysis of 16,000 entrée orders revealed statistically significant decreases in calories purchased at four of six restaurants (the average entrée ordered post labeling had about 15 fewer calories); total calories ordered were not evaluated.

Cross-sectional comparing labeled vs. unlabeled sites. Auchincloss et al. (38) collected dinnertime receipts from 648 customers at two locations of a full-service restaurant chain in Philadelphia (labeled) and five outside of Philadelphia (unlabeled). Customers at labeled restaurants ordered statistically significantly fewer calories (151-calorie reduction) than those at unlabeled restaurants; results held when different propensity scoring methods were used to improve causal inference (40).

Rendell and colleagues asked 127 participants at a fast-casual chain restaurant in New York (labeled) and 118 participants at the same restaurant in Connecticut (unlabeled) to complete a survey as they exited the restaurant identifying which lunch items they ordered. The researchers did not observe a statistically significant difference when comparing calories ordered between restaurants over a 6-month period (39).

Cafeteria settings

There were nine cafeteria studies (Table 2) (41-49). Eight evaluated menu labeling before and after implementation (42-48), and one was a quasi-real-world RTC (49). Eight studies reported fewer calories purchased after labeling (42-49).

School/university cafeteria, pre/post design without comparison site. Chu et al. (45) examined calories ordered in response to labeling 12 entrees with calories, serving size, fat, protein, and carbohydrates in a university cafeteria. Sales data were collected over 6 weeks (2 weeks each for baseline, labels, and no labels). After labeling, there was a statistically significant 12-calorie decrease in average entree calories ordered; information on overall calories purchased was not available.

Hammond et al. (44) conducted a longitudinal study in a university cafeteria where 159 students completed surveys during a 1-week baseline period followed 6 weeks later by a 1-week period when calorie labels were displayed during lunch and dinner. Calorie labels were associated with a statistically significant decrease of 91 calories ordered and 98 calories consumed (based on self-reported intake).

Hunsberger and colleagues (42) examined calorie labeling in a rural, low-income middle school cafeteria, with a baseline period of 1 month, followed by 1 month of calorie labeling. Consumption was measured at the group level by weighing food before and after meal service. There was a statistically significant drop in estimated mean calories ordered per student (based on an average of 531 students daily) from 668 to 621.

In one study, 299 female undergraduates completed a survey 1 month before and 1 week after calorie labels were displayed in a cafeteria. Results revealed a nonstatistically significant mean reduction of 58 calories post labeling (44).

In one of the earliest studies of calorie labeling, Milich et al. (46) studied 450 female employees at a hospital cafeteria. Two weeks of baseline data collection were followed by 1 week of an unexpected price increase (5-10 cents on about half of the items) followed by 1 week of calorie labels. The mean calories purchased during the baseline, price increase, and calorie information periods were 507, 525, and 459, respectively. Calorie labels were associated with statistically significantly fewer calories purchased relative to the price increase week ($P = 0.008$; a more valid comparison because prices were held constant in both weeks) and marginally statistically significantly fewer calories purchased relative to no intervention ($P = 0.057$, when prices also differed).

Nikolaou and colleagues (43) followed 120 students dining at a college cafeteria over 2 years. No calories were displayed in year one, calorie labels were introduced for 20 weeks in year two, then removed for 6 weeks, and then displayed for 10 weeks along with posters showing daily calorie requirements for young adults. Females ordered 709, 628, and 534 mean calories and males ordered 734, 692, and 622 calories for the no label, calorie label, and calorie label plus daily caloric recommendation phases, respectively. Both calorie label phases statistically significantly differed from the control phase and from each other.

Workplace cafeteria, quasi-real-world RCT. VanEpps et al. (49) conducted an RCT of 249 corporate employees who placed lunch orders from the on-site cafeteria through a website over 4 weeks. Employees were randomized to view menus with either (1) no labels, (2) calorie labels, (3) traffic lights, or (4) calorie labels plus traffic lights. Each of the label types statistically significantly reduced calories ordered by about 60-78 calories relative to no labels.

Workplace cafeteria, pre/post design without comparison site. Schmitz and Fielding (47) compared a 2-week baseline period without labels to a 2-week period of labeling calories, sodium, and fat at a large worksite cafeteria in southern California. Based on 823 meals, statistically significantly fewer (71 kcal) calories were ordered per tray following labeling.

Ussher et al. (48) compared the calorie content of breakfast and lunch ordered at a hospital cafeteria in Ireland before and after calorie labeling. Based on 999 customers before labeling and 1,005 customers after labeling, males purchased statistically significantly fewer calories at both meals, and females purchased statistically significantly fewer calories for lunch.

Laboratory and simulation settings

A total of 21 studies were conducted in simulation or laboratory settings (Table 3). Of the ten laboratory studies, five measured hypothetical food selections (50-54) and five measured actual food selections and consumption (55-59). Eleven simulation studies measured hypothetical food selections (60-70). The laboratory and simulation results are heterogeneous, even among studies with the strongest designs, and many are limited by small sample sizes.

Laboratory, actual food selection and consumption. Hammond et al. (55) randomized 635 Canadian adults to select a free dinner from one of four Subway menus: (1) control, (2) calorie information, (3) calories in traffic light format, or (4) traffic lights for calorie, sodium, fat, and sugar content. Food intake was measured. There were no statistically significant differences in calories ordered, but calorie labels led to fewer calories consumed compared to control.

Harnack et al. (59) randomized 594 participants ≥ 16 years old to either a modified McDonald's menu with calorie labels plus a daily recommended calories statement or no labels; typical or modified menu pricing structures was also manipulated. Consumption of actual McDonald's meals was measured. Calories ordered and consumed did not statistically significantly differ across conditions.

James et al. (56) recruited 300 young adults to eat lunch at a lab and randomized them to menus with no labels, calorie labels plus a statement of daily recommended caloric intake, or labels identifying how many minutes of brisk walking would be needed to burn off the calories in each item. Consumption was measured and postmeal intake was assessed with a dietary recall interview. Only the exercise labels resulted in statistically significantly fewer mean calories ordered and consumed relative to the control group, but it did not statistically significantly differ from the calorie label group.

Platkin et al. (57) recruited a very small sample of 62 female participants with overweight or obesity from a college campus to order and eat a Burger King lunch in the lab. They returned 1 week later for a second lunch, when they were randomized to menus with either no labels, calorie labels, or calories plus physical activity labels (minutes to burn off calories by walking). At the second lunch, the no label, calorie, and physical activity groups ordered 25, 206, and 162 fewer calories, respectively. Mean calories consumed at the second lunch were 995 (control), 899 (calorie labels), and 841 (physical activity labels). These differences were not statistically significant.

Roberto et al. (58) randomized 295 participants to one of the following menus: (1) control, (2) calorie labels, or (3) calorie labels and a statement of recommended daily caloric intake. Food intake was measured, and intake after dinner was assessed via a dietary recall interview. Although participants in both calorie label groups ate statistically significantly fewer calories at dinner compared to the control group, those who received a menu with only calorie labels ate more calories after dinner. Only the group viewing the calorie recommendation ate statistically significantly fewer overall calories at dinner plus after dinner (approximately 250 kcal reduction) compared to the control group.

Laboratory, hypothetical food selection. A study by Gerend et al. (50) randomly assigned 288 college students to a McDonald's-like menu that either did or did not have calorie information. Participants made hypothetical choices based on three different dinner descriptions (quick dinner, participant is very hungry, or not too hungry). The effects of calorie information were similar across the three scenarios, so data were combined. There was a statistically significant interaction such that men were unaffected by calorie labels, but women ordered 146 fewer calories when shown labels.

Lee and Thompson (51) recruited 643 undergraduate students for an online survey. Participants were randomized to one of three groups: (1) no nutrition information, (2) calorie information, or (3) calorie information plus miles needed to burn off an item's calories and ordered from a hypothetical fast-food menu. Total calories ordered did not statistically significantly differ across groups.

Reale and Flint (52) recruited 61 people with obesity from a weight management service and conducted a randomized crossover trial in which participants were asked to place a hypothetical order from one of the following four menu conditions: (1) no label, (2) calorie label, (3) information on fat, protein, carbohydrates, salt, and fiber, or (4) energy expenditure label. Participants were exposed to each menu condition on a separate day, starting with the no label condition on the first day. All three experimental conditions resulted in a statistically significant reduction in calories ordered compared to the control group. The calories group had a 26% reduction.

Stutts et al. (53) randomized 236 children (6-11 years old) to a McDonald's menu with either no labels, calories and fat information, or a healthy heart symbol placed next to healthier menu items. Calorie labels had no effect, but the healthy heart symbol led to statistically significantly fewer calories ordered.

Wei and Miao (54) randomly assigned 189 participants to place hypothetical orders from menu boards with or without calorie information from either a restaurant perceived as "healthful" (i.e., Subway or Panera) or "unhealthful" (i.e., McDonald's or Wendy's). Calorie labels led to a 96-calorie reduction when ordering from healthful restaurants, but there was no statistically significant effect when ordering from unhealthful restaurants.

Simulation, hypothetical food selection. Antonelli and Viera (60) randomized 823 parents of a child aged 2 to 17 to one of four online fast-food menus: (1) no labels, (2) calorie labels, (3) calories plus minutes of walking required to burn off calories, or (4) calories plus miles to walk. All labeling conditions resulted in statistically significantly fewer hypothetical calories ordered compared to no labels, with the calorie label leading to 380 fewer calories ordered. Minutes of walking led to 440 fewer calories ordered, while miles of walking led to 370 fewer calories ordered compared to no labels. The labels did not statistically significantly differ from one to another (60,70).

Dodds et al. (60) randomly sampled 329 Australian parents with a child (3-12 years) from a larger random study sample. After a telephone interview, participants were randomized to receive a fast-food menu in the mail with either (1) no labels, (2) kilojoule labels plus a statement indicating the daily energy intake for adults, or (3) traffic light labels. The labels had no effect on total energy selected for parents or children.

Downs et al. (62) recruited 921 pedestrians from busy public locations using a mobile research lab and randomized them to one of the following ten groups: (1) control group, (2) basic information (three subgroups, including calorie labels), (3) contextualized numeric information (three subgroups), and (4) heuristic cues (three subgroups, e.g., traffic light ratings). Participants made hypothetical snack selections. There was no effect of calorie labels, but contextualized numeric information and heuristic cue labeling led to a statistically significant decrease in calories ordered compared to the control group.

Dowray et al. (63) randomized 804 online participants to one of four menus with either (1) no labels, (2) calorie labels, (3) calorie labels plus miles of walking, or (4) calorie labels plus minutes of walking needed to burn calories in each item. Only the miles of walking label led to statistically significantly fewer hypothetical calories ordered relative to no label, but it did not differ from the other labels.

Haws and Liu (64) randomized 245 online participants to calorie labels (present vs. absent) or pricing (linear vs. quantity discounted, such that price per unit of a product was lower for larger portion sizes). Participants made a hypothetical dinner choice from a menu with ten entrees, each with a full- or half-size option. People ordered statistically significantly fewer calories when viewing labels, and calorie labeling plus linear pricing led to the fewest calories ordered.

Liu et al. (65) randomly assigned 418 online participants to one of four menus: (1) no labels, (2) calorie labels, (3) calorie labels arranged from low to high, or (4) calorie labels arranged from low to high plus red or green traffic lights indicating higher/lower-calorie choices. All label conditions included a statement about recommended daily caloric intake. None of the label groups statistically significantly differed from control, but when analyses were repeated controlling for gender, hunger, and reported frequency of nutrition label use, rank-ordered calorie labels led to statistically significantly fewer calories ordered (1,606 calories) compared to no labels (1,760 calories).

Morley et al. (66) randomized 1,294 online Australian participants to one of five hypothetical menus: (1) no information, (2) kilojoule information, (3) kilojoule information plus each item's percentage of recommended daily intake, (4) kilojoule information plus traffic lights, or (5) kilojoule information plus each item's percentage of recommended daily intake plus traffic lights. Only calories and calories plus traffic lights led to statistically significantly fewer calories ordered (117 and 119 fewer calories, respectively) relative to no labels.

Pang and Hammond (67) randomized 213 undergraduate students to one of four Tim Horton's snack menus: (1) control, (2) calorie information, (3) calorie information plus recommended daily caloric intake statement, or (4) calorie information plus a physical activity label. Only calorie labels and calories with a daily intake statement led to statistically significantly fewer calories ordered compared to control. None of the label groups statistically significantly differed from one another.

Roseman et al. (68) recruited 302 urban pedestrians from a downtown street of a medium-sized city in the United States. Participants completed a survey and were randomized to either a calorie-labeled or unlabeled menu that displayed seven items from several fast-food restaurants. There were no statistically significant differences in hypothetical calories ordered.

Tandon et al. (69) randomized 99 parents in a primary care pediatric clinic in Seattle, Washington, to a McDonald's menu with or without calorie labels. Calorie labels led parents to hypothetically order 102 fewer calories for their children compared to no labels. The parents' choices for themselves did not differ.

Changes in restaurant offerings

Five studies examined changes in the calories of restaurant menu offerings after local menu labeling regulations were implemented or in advance of national implementation (Table 4) (71-75). Two studies evaluated menu offerings in which local menu labeling laws were implemented (73,75); one of these studies included a control comparison (75). Three studies examined restaurant nutrition data at the national level (71,72,74). No studies looked at cafeteria offerings in response to calorie labeling.

Pre/post design with comparison site(s). Namba et al. (75) examined nine fast-food restaurant chains in 2005 and again in 2011 post local labeling. Five of these chains had some labeled locations, while four had restaurants not subject to labeling. Although the mean calories of menu items offered in labeled cities did not change, the proportion of healthy items statistically significantly increased in restaurant chains with some labeled locations (from 3% to 20%).

Restaurant trends where labeling is present, without comparison site(s). Bruemmer et al. (73) examined the calorie content of menu items at 37 chain restaurants in King County, Washington, and found a statistically significant decline in overall average entrée calories (41 fewer calories post labeling; 73 fewer calories at full-service restaurants and 19 fewer at quick-service restaurants) when comparing 6 and 18 months post labeling.

National restaurant trends in advance of national menu labeling. Bleich et al. (71) reported that the mean calorie content of national chain restaurant menu items available between 2012 AND 2014 did not change, but new items in 2013 and 2014 had fewer calories than items only available in 2012. In addition, cross-sectionally, chains with voluntary labeling ($n = 5$) had fewer calories than those without labeling ($n = 61$) (72).

Wu and Sturm (74) tracked changes in the energy and sodium content of US chain restaurant main entrees between spring 2010 (right after the passage of national menu labeling legislation) and spring 2011. They found no overall changes, but fast-food restaurants statistically significantly decreased mean energy in children's menu entrees by 40 calories, whereas upscale restaurants statistically significantly increased mean energy in children's menu entrees by 46 calories.

Discussion

The strongest research design to evaluate menu labeling is a randomized controlled field experiment. Unfortunately, only one such study was identified, and the sample size was too small to be able to detect even medium to large effects (22). Two other quasi-real-world randomized controlled field experiments of menu labeling demonstrated that it led to a statistically significant and fairly large reduction in calories ordered (23,49). The best-designed natural experiment with a large sample size reported a 15-calorie reduction in response to calorie labeling among Starbucks customers (24). In contrast, a well-powered, well-designed natural experiment at taco restaurants reported a null effect (25). Although two other well-designed natural experiments reported null effects of calorie labeling at fast-food restaurants, both studies were only powered to detect large effects of calorie labeling (26,29). Further, there was only one real-world, full-service chain restaurant analysis with an adequate sample size, which found that calorie labeling was associated with a 150-calorie reduction, but this study was limited by a cross-sectional design (38). Although other reviews have concluded that menu labeling has little impact on fast-food purchases (13-16), there is an extraordinary dearth of well-designed and adequately powered studies to truly test this hypothesis in both fast-food and full-service chain settings.

In general, laboratory/simulation studies produced similar mixed results. Although these studies used RCT designs, many were also limited by small sample sizes. Many laboratory studies of fast-food orders generally reported no change in calories ordered (51,57,59,61,68), while laboratory studies mimicking full-service chain restaurants or restaurants typically perceived as healthier found labels led to fewer calories ordered or consumed (55,58,67). These divergent findings across restaurant settings and studies may emerge because restaurant type affects calorie label use or attracts different types of patrons. It is possible that patrons of coffee chains, full-service sit-down chains, or fast-food outlets that market themselves as "healthy" attract patrons with higher incomes, education levels, and/or health consciousness who are more likely to use labeling (76-79). Secondary analyses and laboratory studies also report that awareness and/or use of menu labels is higher among certain consumers, such as women and those with higher incomes and health consciousness. It is also possible that calorie labeling is more influential in certain settings. Fast-food customers, for example, may enter the restaurant knowing what they want to order, while full-service sit-down patrons may spend more time reviewing the menu before making their decision. In addition, full-service chain restaurants, compared to fast-food, are more likely to have very-high-calorie items, even for items like salads that most people think are low-calorie. There was also more consistent evidence that calorie labeling can promote lower-calorie choices in cafeteria settings, perhaps because people eat there more regularly and are less likely to view the meal as a "treat" compared to dining out. The sole randomized controlled cafeteria field experiment reported a statistically significant and substantial reduction in response to calorie labels, but this may have been because people were ordering food ahead of time, which might have enabled them to exert more control over their decisions compared to ordering on impulse when in the cafeteria (49). Many of the other cafeteria studies did not have comparison sites to control for secular trends, suggesting a need for more research in these settings.

Fewer studies have examined modified calorie information (e.g., daily recommended intake statement) relative to calorie labels, and these results are highly variable across settings (22,23,31,33,35,43,49,51-53,55-67,70). Presumably, making calorie information easier to understand and more accessible to a greater range of individuals, particularly those with lower numeracy levels, would increase the reach and impact of such information, but real-world RCTs are needed to know for sure.

Finally, although preliminary evidence suggests that recent calorie labeling regulations (enacted or anticipated) may be correlated with healthier restaurant offerings, the small number of studies, considerable differences in design, lack of comparison sites, and heterogeneity across included restaurants make it difficult to draw conclusions at this point.

This review has several limitations. First, we may not be capturing a number of null studies because of publication bias. In addition, article screening was conducted by a single author, which could have led to a biased sample; however, all potential articles for inclusion were reviewed by a second author and adjudicated by a third, as necessary. Strengths of this review include the examination of a large number of studies of both consumer and restaurant responses to calorie labeling across multiple settings and comparing modified to absolute calorie information.

Taken together, evaluations of menu labeling in different settings are mixed, and much of the research is plagued by inadequate study designs and/or underpowered studies, highlighting a considerable need for more research. First, data from well-powered RCT field experiments or natural experiments testing menu labeling are needed, especially at full-service chain restaurants. These studies are very difficult to conduct because they require the cooperation of a food retail establishment that has not already implemented labeling. Second, we do not have a good understanding of how people might compensate later if they reduce calories at one meal in response to menu labeling, and nearly all real-world studies only assessed calories purchased, not consumed. Third, because much of this legislation is fairly recent, and the federal law's implementation date is May 2018, there are also limited data on the long-term impacts of calorie labeling. Fourth, more research is needed to understand whether different presentations of this information can increase its impact or whether accompanying educational campaigns might increase the effect of menu labeling. Fifth, we lack good data on whether calorie labeling in other settings impacted by the regulation, such as supermarkets, influences purchases. Finally, research examining impacts on BMI in jurisdictions that have implemented menu labeling would be useful. Currently, there is one such study that we are aware of. Restrepo (80) used data between 2004 and 2012 from 103,220 respondents from the behavioral risk factor surveillance system who self-reported height and weight. Using a natural experiment design, the authors compared BMI trends over time in NYC and nearby counties with and without calorie labeling. The results revealed that, on average, calorie labeling laws were associated with a statistically significant reduction of 0.38 BMI units. This further suggests that underpowered studies may not be picking up meaningful reductions in calories purchased at restaurants.

Conclusion

Overall, because of a lack of well-powered studies with strong designs, the jury is still out on the degree to which menu labeling encourages lower-calorie purchases and whether that translates to a healthier population. Although the limited existing research finds little evidence of menu labeling shifting fast-food purchases, there are more promising findings that it may influence consumers at certain types of restaurants and in other types of establishments such as cafeterias. It is difficult to know what a meaningful reduction in calorie intake amounts to, particularly when it is hard to measure how people compensate over the course of a week. Researchers have estimated that if we want to return to 1970 levels of excess weight in the population, adults would need to consume 220 fewer calories daily (81), while children would need to consume 165 fewer calories daily (82). Reducing consumer purchases in chain restaurants by even a small amount may help reduce this excess calorie intake. Finally, menu labeling may encourage restaurants to offer lower-calorie items, but it is currently unknown whether studies focused on calorie changes in chain restaurants are capturing responses to menu labeling legislation (enacted or anticipated) rather than responses to other forces encouraging restaurants to change their menus. O

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