SOCIAL SCIENCES

Mandatory labels can improve attitudes toward genetically engineered food

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The prospect of state and federal laws mandating labeling of genetically engineered (GE) food has prompted vigorous debate about the consequences of the policy on consumer attitudes toward these technologies. There has been substantial debate over whether mandated labels might increase or decrease consumer aversion toward genetic engineering. This research aims to help resolve this issue using a data set containing more than 7800 observations that measures levels of opposition in a national control group compared to levels in Vermont, the only U.S. state to have implemented mandatory labeling of GE foods. Difference-in-difference estimates of opposition to GE food before and after mandatory labeling show that the labeling policy led to a 19% reduction in opposition to GE food. The findings help provide insights into the psychology of consumers' risk perceptions that can be used in communicating the benefits and risks of genetic engineering technology to the public.

INTRODUCTION

Despite widespread belief among scientists that genetically engineered (GE) foods are safe to eat, consumers remain less convinced (*1*–*3*). Perhaps in response, in 2016 legislative sessions, 70 bills were introduced in 25 states addressing the labeling of GE foods (*4*). Vermont's law, VT H112, passed in 2014 and implemented on 1 July 1 2016, was the only state labeling initiative to go into effect (*5*). Federal legislation, signed into law by President Obama on 27 July 2016, superseded all pending state legislation, and the Vermont law was no longer in effect after that time (*6*). Labels on packaged goods persisted for months and are still seen on some packaging in Vermont. National standards for the federal law are currently being developed by the U.S. Department of Agriculture.

Many scientific organizations have opposed the mandatory labeling of GE food, including the American Association for the Advancement of Science (*7*). However, a majority of consumers have consistently expressed desires to label GE foods in polls (*8*–*13*), although not in votes on ballot initiatives. A primary concern expressed with mandatory labels is that they might signal that GE food is unsafe or harmful to the environment (*14*–*21*). An opposing view suggests that labels may give consumers a sense of control or improve trust, lowering perceived risk of GE food (*22*–*26*). Empirical support for these arguments, both for and against labeling, has been mixed (*18*, *19*, *24*, *27*–*29*).

The objective of this article is to provide causal evidence on the impact of mandatory genetic engineering labeling on consumer attitudes toward GE food using data on consumers' real-world exposure to labels in the only state where mandatory labels have been enacted. In Vermont, labels were required to have a simple disclosure, either "produced using genetic engineering" or "partially produced using genetic engineering." Time-series, cross-sectional data from a series of surveys with 7871 consumers conducted nationwide and in Vermont were combined. These data enable the calculation of a difference-in-difference estimate of the effect of mandatory labels. We estimate the difference in consumer attitudes toward GE food in Vermont versus the rest of the United States before and after mandatory GE labels appeared on the shelf in Vermont.

Attitudes toward GE food were measured using a one-to-five scale of very supportive to very opposed in Vermont and very unconcerned to very concerned in the rest of the United States. Differences in question format are controlled via a location-specific fixed effect. The difference-in-difference estimate is obtained from a multiple regression framework, where dummy variables for location (Vermont versus the rest of the United States) and presence of mandatory labels (time periods before versus after mandatory labels appeared in Vermont) are included as explanatory variables. The coefficient on the interaction of two indicator variables is the difference-in-difference estimate.

RESULTS

Using two data sets containing information from time periods before and after mandatory labeling occurred in Vermont and a national database for the same period that did not include Vermont, we estimated a difference-in-difference model to identify how consumer opposition toward GE technology changed over time. Table 1 reports the results associated with key variables of interest in this study. To check for sensitivity and the robustness of the results and to test the validity of the assumptions underlying the difference-in-difference estimate, the table reports results from five model specifications. In model 1, we included time, place, and policy variables. In this simple specification, we estimated the difference-in-difference effect at −0.282, meaning that opposition toward GE food, measured on the five-point scale, fell after mandatory labels were enacted relative to the change in consumer concern toward GE food in the rest of the United States. One of the assumptions of the difference-in-difference model is stable composition of treatment and control groups before and after the policy change. To control for group makeup, in model 2, we added demographic variables to the specification. These include age, educational attainment, gender, race, family composition, income, and political affiliation. Even after these controls, the difference-in-difference effect remains stable at −0.264.

To test and control for the parallel trends assumption in the difference-in-difference estimate, model 3 adds a time trend to model 2, and model 4 adds location-specific trends to model 2. When location-specific trends are added to control for the possibility that opposition to GE food in Vermont was already falling at a faster rate before labeling, the difference-in-difference estimate, −0.594, suggests an even larger decline in opposition to GE food in Vermont after labeling. Finally, to control for possible contamination of the control group via spillover effects if consumers in states surrounding Vermont were also exposed

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to labels, model 5 excludes data from locations proximal to Vermont (Massachusetts, Maine, Connecticut, New York, and New Hampshire); otherwise, the specification is as model 4, and the estimated difference-in-difference effect remains stable.

Regardless of the specification, the interaction effect, indicating the impact of the mandatory labeling policy on consumer opposition to GE technologies in Vermont relative to the rest of the United States, is significant and negative. The results indicate that mandatory labels decrease opposition to GE food in Vermont. Figure 1 shows this graphically using estimates from model 4. Using the predicted value of support/opposition after labeling in Vermont (3.077) and given the estimated difference-in-difference effect of −0.594, mandatory labeling in Vermont led to a 19% decrease in opposition toward GE technologies used in food production.

Table 1. Difference-in-difference estimate of the effect of mandatory labeling from multiple regressions. Numbers in parentheses are SEs. "After labels" is a variable that takes the value of 1 for responses from dates after July 2017 and 0 for dates before this time period, and "Vermont" is a variable that takes the value of 1 for responses from Vermont and 0 for responses from all other states.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	3.229** (0.023)	3.122** (0.069)	3.081** (0.073)	3.156** (0.076)	3.172** (0.078)
After labels	0.045 (0.036)	0.017 (0.036)	−0.048 (0.054)	0.074 (0.061)	0.060 (0.066)
Vermont	0.625** (0.038)	0.653** (0.042)	0.651** (0.042)	0.441** (0.066)	0.417** (0.068)
After labels × Vermont†	−0.282** (0.062)	−0.264** (0.061)	−0.262** (0.061)	−0.594** (0.102)	−0.579** (0.105)
Demographics	No	Yes	Yes	Yes	Yes
Overall trend	No	No	Yes	No	No
Location-specific trends	No	No	No	Yes	Yes
Exclude states near Vermont	No	No	No	No	Yes
R^2	0.04	0.076	0.076	0.078	0.081
N	7871	7871	7871	7871	7171

**$P \leq 0.01$ (statistically significant). †The coefficient associated with the interaction of the location and time dummy variables is the difference-in-difference estimate, the difference in opposition to GE in Vermont and opposition to GE in the rest of the United States after labels appeared minus the opposition to GE in Vermont and opposition to GE in the rest of the United States before labels.

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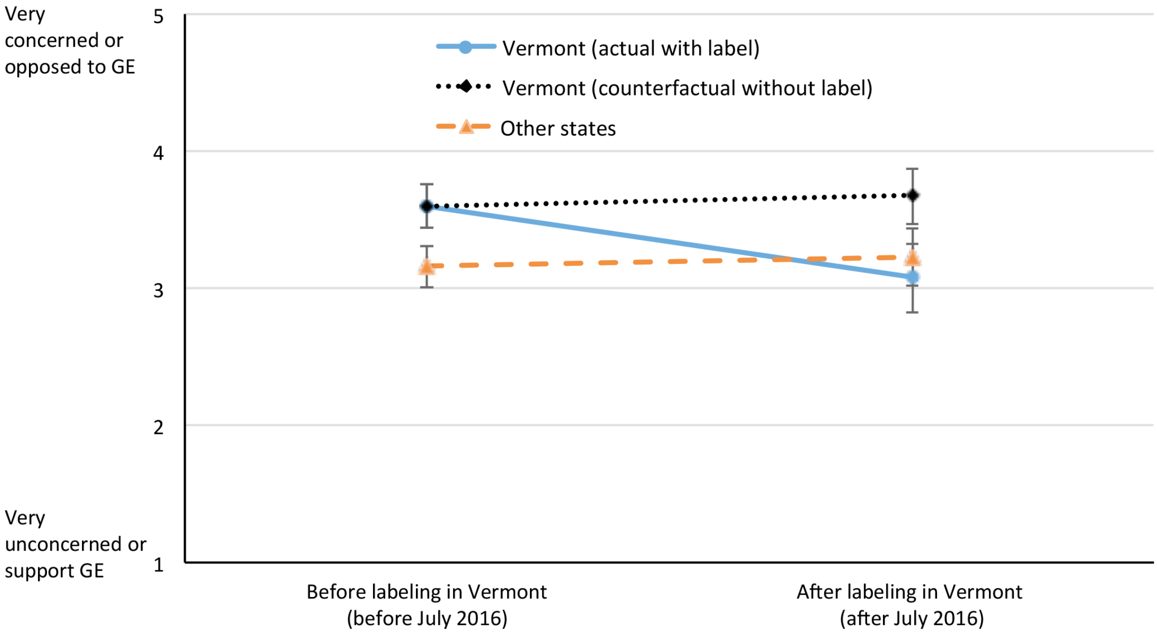

Fig. 1. Estimated effects of mandatory labels on concern/opposition to GE foods in Vermont based on the difference-in-difference model applied to cross-sectional and time-series surveys of 7871 individuals, controlling for demographics and location-specific trends.

DISCUSSION

Our goal with this study was to determines the impact on consumer attitudes toward the use of GE technologies in food production using U.S. national data from states not requiring GE labels and data from a state where consumers were exposed to mandatory GE labels. All previous research has relied on hypothetical labeling scenarios, regardless of whether the methodology used was survey- or experiment-based. The findings are that mandatory labels providing simple disclosures lead to reductions in opposition to GE. This study provides evidence that a simple disclosure, one of the suggestions for the standards being developed at the federal level, is not likely to signal to consumers that GE foods are more risky, unsafe, or otherwise harmful than before label exposure and might, in fact, do the opposite. This national study cannot identify why this change occurred, but the findings are consistent with previous research suggesting that labels give consumers a sense of control, which has been shown to be related to risk perception. Whether labels improve a sense of control, improve trust, or operate by some other psychological mechanism is a question we leave to future research. Here, we show that in real-world exposure to GE disclosure, attitudes toward GE food improved.

MATERIALS AND METHODS

Data

Data originated from phone surveys conducted in Vermont in three time periods before mandatory labels appeared on grocery shelves (March 2104, March 2015, and March 2016) and two time periods after mandatory labels appeared (November 2016 and March 2017). Table 2 identifies the number of observations in each time period for both the Vermont sample and the national sample, for a total of 7871 observations used in the multivariate analyses. These data were date-matched with data conducted from a nationwide online survey of consumers in the same time periods. Vermont observations were removed from the national online survey. Research protocols for the national and Vermont data were approved by the respective institutional review board offices.

In Vermont, respondents were asked, "Overall, do you strongly support, somewhat support, have no opinion, somewhat oppose, or strongly oppose the use of GMOs in the food supply?" Responses were recorded on a five-point scale: 1 = strongly support, 2 = support, 3 = neither support nor oppose, 4 = oppose, and 5 = strongly oppose. In the nationwide online survey, respondents were asked, "How concerned are you that the following pose a health hazard in the food that you eat in the next two weeks?" One of the items was "genetically modified food," and responses to this question were coded as follows: 1 = very unconcerned, 2 = somewhat unconcerned, 3 = neither concerned nor unconcerned, 4 = somewhat concerned, and 5 = very concerned. Table 2 shows the number of observations and the mean and SD of the opposition/concern variables by location and time period.

Table 2. Mean level of concern or opposition by location and time period.

Time period	Location	*N* obs	Mean	SD	Minimum	Maximum
March 2014	Rest of the United States	1032	3.188	1.347	1	5
	Vermont	522	3.741	1.007	1	5
March 2015	Rest of the United States	1038	3.335	1.297	1	5
	Vermont	574	3.775	1.037	1	5
March 2016	Rest of the United States	1029	3.162	1.354	1	5
	Vermont	658	4.012	1.183	1	5
November 2016	Rest of the United States	1002	3.360	1.304	1	5
	Vermont	405	3.474	1.367	1	5
March 2017	Rest of the United States	1015	3.188	1.331	1	5
	Vermont	596	3.715	1.159	1	5

Simple difference-in-difference calculations

The use of different survey formats (phone versus online) and questions (opposition versus concern) would be problematic if only one time period of data were available. However, interest in this analysis rests in comparing differences in responses in Vermont and the rest of the United States over time. The estimate of the initial difference between Vermont and the rest of the United States controls for differences in question and survey format before proceeding to a calculation of difference-in-difference estimates. To illustrate, Table 3 reports sample averages by location and pre- and post-policy to calculate simple difference-in-difference estimates, not controlling for any confounders.

Before mandatory labels appeared in Vermont (before July 1, 2016), the difference in opposition in Vermont and concern in the rest of the United States was 0.617, suggesting that consumers were more opposed/concerned in Vermont than elsewhere. However, this difference might also reflect differences in question or survey format across the two locations. After July 1, the difference was 0.338. Because the same question formats were used both before and after, the difference-in-difference estimate netted out the differences in question/survey format. Data in Table 3 suggest that opposition of GE food in Vermont fell 0.337 − 0.617 = −0.279 relative to concern for GE food among people in the rest of the United States. Note that, by definition, this estimate is exactly the same as that from model 1 in Table 1.

Table 3. Differences in mean level of concern or opposition by location and time period.

Timing of labels	Location	*N* obs	Mean
Before	Rest of the United States	3099	3.229
	Vermont	1754	3.854
	Difference		0.625
After	Rest of the United States	2017	3.273
	Vermont	1001	3.617
	Difference		0.344
	Difference-in-difference		−0.281

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We also note that, in Vermont, there was no ballot initiative. Lawmakers passed the labeling law in spring of 2014, which was implemented on 1 July 2016. Therefore, there were no accompanying campaigns by pro- or anti-labeling groups designed to sway voter's attitudes toward GE. The Vermont sample (only) contained a question about respondents' behaviors with regard to information about GE both before and after labeling. Respondents were asked whether they sought information, saw information if it caught their eye, heard about GE but did not pay attention, or had never seen any information. We created a dummy variable coded as 1 if respondents sought or saw information and 0 otherwise for both the before and after labeling time periods. There was no significant difference between seeing information about GE before and after the labels were seen in the marketplace (χ^2 = 0.45; $\sigma > 0.05$).

Table 4. Characteristics of respondents by time and location.

Variable	Vermont		Rest of the United States	
	Before	After	Before	After
Age (years)				
18–24	1.7%	5.0%	11.6%	7.8%
25–34	4.3%	9.0%	21.7%	23.5%
35–44	9.3%	10.8%	19.2%	17.1%
45–54	17.0%	18.4%	17.5%	15.1%
55–64	26.2%	23.7%	15.2%	17.4%
65–74	23.5%	18.0%	12.6%	15.1%
75+	13.9%	10.4%	2.2%	4.0%
College degree	50.6%	49.0%	22.5%	22.4%
Female	52.6%	51.8%	49.7%	56.9%
White	91.2%	89.4%	78.8%	79.3%
Children in household	24.3%	27.7%	31.0%	32.9%
Above median income	51.4%	53.2%	54.1%	50.7%
Republican	14.3%	13.7%	26.7%	29.4%
Democrat	26.6%	27.4%	39.8%	42.1%
Independent	31.0%	23.6%	29.9%	26.4%

Multiple regression analysis

The same analysis can be carried out using a multiple regression framework, which can be further augmented with controls to test the assumptions of the difference-in-difference estimate (*30*, *31*). The general equation is

$$y_{i,t} = \beta_0 + \beta X_i + \nu_0 Z + \delta_0 T + \Delta_1 ZT + \varepsilon$$

where y represents the level of concern or opposition toward GE food, the dependent variable of interest. X_i represents a vector of time-invariant demographic variables. Z is a dummy variable indicating the policy intervention group (Vermont) that captures possible differences between the treatment and control groups before the labeling policy. T is a dummy variable indicating the time periods after labeling and captures aggregate factors that might cause changes in consumer preferences, even in the absence of a labeling policy. The interaction term ZT multiplies the presence of the labeling policy by time, a dummy variable equal to one for those observations in the labeling policy treatment group after the implementation of the policy. The coefficient on the interaction term, Δ_1, is the measure of interest.

The estimates β represent the fixed effects of respondent demographic characteristics. ν_0 is the estimate of differences in the control and treatment group at baseline. δ_0 is the estimate of the passage of time. Δ_1 is the effect of the labeling policy. We estimated several specifications of the model, as described below.

Table 4 reports characteristics of the respondents by time and location. These are all dummy variables that were coded 1 if the characteristic is present and 0 otherwise.

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Table 5. Difference-in-difference estimates of the effect of mandatory labeling from ordered logit regressions. Numbers in parentheses are SEs.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
After labels	0.055 (0.051)	0.012 (0.051)	-0.138 (0.077)	0.113 (0.088)	0.096 (0.095)
Vermont	0.831** (0.054)	0.885** (0.061)	0.883** (0.062)	0.471** (0.096)	0.433** (0.098)
After labels × Vermont	−0.354** (0.088)	−0.332** (0.088)	−0.333** (0.088)	−1.023** (0.148)	−1.005** (0.153)
Demographics	No	Yes	Yes	Yes	Yes
Overall trend	No	No	Yes	No	No
Location-specific trends	No	No	No	Yes	Yes
Exclude states near Vermont	No	No	No	No	Yes
N	7871	7871	7871	7871	7173

**$P \leq 0.01$ (statistically significant).

The multiple regression estimates are likely to be most robust (*32*). Because our dependent variable was ordinal, however, ordered logit estimates were also conducted to check for robustness. The ordered logit estimates are shown in Table 5. The estimates were similar to the ordinary least squares specifications and support the finding that mandatory labeling led to less opposition to GE in Vermont after mandatory labeling was enacted relative to changes in the rest of the United States.

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Acknowledgments

Funding: Monetary support for the Vermont survey was provided by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award numbers VT-H01404, VTH01811, and VTH02113. Monetary support for the national survey data was provided via the Willard Sparks Chair at Oklahoma State University and a grant from the U.S. Department of Agriculture, National Institute of Food and Agriculture, Agriculture and Food Research Initiative. **Author contributions:** J.K. conceptualized the study, collected the Vermont data, contributed to data analysis, and co-wrote the manuscript. J.L.L. collected the national data, contributed to data analysis and reporting, and co-wrote the manuscript. **Competing interests:** The authors declare that they have no competing interests. **Data and materials availability:** All data needed to evaluate the conclusions in the paper are present in the paper. Additional data related to this paper may be requested from the authors.

Submitted 5 October 2017
Accepted 4 June 2018
Published 27 June 2018
10.1126/sciadv.aaq1413

Citation: J. Kolodinsky, J. L. Lusk, Mandatory labels can improve attitudes toward genetically engineered food. *Sci. Adv.* **4**, eaaq1413 (2018).

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Science Advances

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Sci Adv **4** (6), eaaq1413.
DOI: 10.1126/sciadv.aaq1413

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