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Implementing the National Bioengineered Food Disclosure Standard: Will Consumers Use QR Codes to Check for Genetically Modified (GM) Ingredients in Food Products?

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The National Bioengineered Food Disclosure Standard of 2016 mandates the disclosure of Genetically Modified (GM) ingredients in food products in the US by including text, a symbol, or a digital link such as a Quick Response (QR) code on product labels. Many food manufacturers will use QR codes that connect to a website, because they enable provision of detailed contextual information about GM ingredients. However, critics argue that this approach is inadequate because many consumers will be unable/unwilling to use QR codes to access information. Using a telephone survey of US adults (N=1,011), this study finds that consumers likely to use QR codes to check for GM ingredients are: those who already use UPC or QR codes, consider GM Organisms to be risky, approve of the mandatory labeling law, and are less likely to buy products with GM ingredients. The study concludes by discussing implications for implementation of the policy.

Key words: consumer intentions, genetically modified organisms (GMO), mandatory GM labeling policy, QR codes for GM labeling, responses to food labeling.

Introduction

The debate over mandatory labeling of genetically modified (GM) foods in the United States has had a protracted and contentious history (Hallman, 1995; Leary, 1992, 1994), resulting in a value-based disagreement about the transparency of GM technology (Bain & Selfa, 2017; Barham, 2002). Advocacy groups supporting mandatory labeling have long asserted that consumers have a fundamental "right to know" whether the products they purchase contain ingredients derived from genetically modified organisms (GMOs), that the majority of consumers favor the mandatory labeling of GM foods, and that because more than 60 other countries have GMO labeling laws, the lack of required labeling of GM foods in the United States places the country out of the mainstream of regulation (O'Neil, 2016). They argue that mandatory labeling would provide greater transparency and offer consumers increased choice, the ability to exercise religious or dietary preferences, and the ability to use market forces to support or oppose the inclusion of GM ingredients in the products they choose to purchase (Hallman, 2000; Hallman & Aquino, 2005; Hemphill & Banerjee, 2014; Kopicki, 2013; Phillips & Isaac, 1998).

Those opposed to required labeling contend that "mandatory labels for GMO food are unscientific, unnecessary, and unconstitutional" (Adler, 2016, p. 26), amounting to compelled commercial speech that unfairly stigmatizes products that contain GM ingredients (Adler, 2016). Opponents of mandatory labeling underscore the broad scientific consensus that GM crops and ingredients derived from them are as safe as those made from their conventionally bred counterparts and are nutritionally equivalent (National Academies of Sciences, Engineering, & Medicine 2016; Snell et al., 2012). They note that because of this 'substantial equivalence,' the US Food and Drug Administration (FDA) has not required the mandatory labeling of GM foods (US FDA, 1992, 2015).

Opponents of mandatory labeling also point out that surveys show that American consumers' knowledge and awareness of GM foods are low and that despite the fact that GM foods have been on the market since the mid-1990s, many are unaware that they are already consuming foods with GM ingredients (Hallman, Cuite, & Morin, 2013; Kennedy & Funk, 2016). They argue that a mandatory label has a 'signaling effect' (Sunstein, 2016) which serves as a de facto 'warning label' (Adler, 2016), implicitly communicating the misleading sense that GMOs are risky (Phillips & Isaac, 1998), falsely alarming consumers (American Association for the Advancement of Science, 2012), and discouraging them from purchasing these products (Adler, 2016; Charles, 2016; Hallman & Aquino, 2005; Phillips & Hallman, 2013; Runge & Jackson, 2000; Sunstein, 2016). In fact, nearly 40% of Americans already believe that "foods

with genetically modified ingredients are generally worse for health than foods with no genetically modified ingredients" (Funk & Kennedy, 2016, p. 46). As such, many consumers may reject products labeled as containing genetically modified ingredients. Capitalizing on this, nearly 16% of new US food and beverage products made non-GMO claims in 2015 (Watson, 2016).

Analyses of the potential economic impacts of mandatory labeling also suggest that the costs of compliance would significantly increase the price of food products (McFadden, 2017). These costs include those related to maintaining strict separation between GM and non-GM crops and ingredients to ensure accurate labeling, (Hallman & Aquino, 2005) and the expense of non-GMO certifications necessary to meet the demands of consumers who wish to avoid products with GM ingredients (Hemphill & Banerjee, 2014). The consumers' willingness to pay for such added expense is yet to be fully explored within the context of GM labeling and could depend on the specific product, process, or application (Costanigro, Deselnicu, & McFadden, 2016).

The National Bioengineered Food Disclosure Standard of 2016

Congress passed legislation in 2016 to create a federal requirement to label food products containing GM ingredients (Charles, 2016). The law was passed, in part, to preempt Vermont's Act 120 (Vermont General Assembly, 2016) which required labeling of GM foods, effective July 1, 2016. It was also enacted to forestall efforts by other states to set their own labeling standards, which the food and agriculture industry feared would lead to a collection of complex, inconsistent, and perhaps contradictory sets of regulations (Plumer, 2016).

Signed into law on July 29, 2016, the National Bioengineered Food Disclosure Standard of 2016 requires the labeling of all food products containing GM ingredients sold in the United States. Although the law does not specify the date by which companies must disclose that their products contain GM ingredients, it instructs the US Department of Agriculture (USDA) to issue regulations necessary to implement the federal disclosure standard by July 29, 2018.

An amendment to the Agricultural Marketing Act of 1946 (7 U.S.C. 1621 et seq.), the law places responsibility for GM food labeling within the USDA rather than the FDA, signaling that the labeling of GM foods is a marketing issue rather than one designed to protect public health. It also gives the Secretary of Agriculture significant discretion in setting the standards for GM food labeling, including determining what qualifies as a 'bioengineered food,' what term should be used to describe such foods, and what amounts of bioengineered food must be present in a product to trigger mandatory labeling (National Bioengineered Food Disclosure Standard, 2016).

Figure 1. QR code.

One of most contentious provisions of the law is that it permits companies selling foods containing GM ingredients to choose the method by which they disclose GM information on their product labels (Bittman, 2016; Charles, 2016; Plumer, 2016; Rosenberg, 2016). Under the law, companies can indicate the presence of GM ingredients in their products using text or a symbol on their labels, or by printing an electronic or digital link such as a universal product code (UPC) or quick response (QR) code on their labels, which connects consumers to disclosure information published on a website. On-package language such as "scan here for more food information" would be required to accompany the QR code (or other digital link; National Bioengineered Food Disclosure Standard, 2016, §293 [a][2][D]). Many food manufacturers are likely to choose to print a QR code on their packaging (e.g., Figure 1) that links to a website as their preferred disclosure method because it offers the opportunity to provide detailed information about GM ingredients to consumers who want it, without potentially stigmatizing products by printing prescribed text or a symbol on their labels (Zhang, 2016).

SmartLabel

Many companies who intend to use QR codes are also likely to choose to make their GM ingredient disclosures using the web-based SmartLabel platform (SmartLabel.org), which was launched in December 2015 and went online in May 2016. SmartLabel was created by

the Grocery Manufacturers Association (GMA) as a transparency initiative designed to provide consumers with desired information about the products they buy (GMA, 2015a). While the GMA says that the initiative was not developed specifically for GMO labeling (Heneghan, 2016), and the National Bioengineered Food Disclosure Standard of 2016 does not explicitly mention the SmartLabel platform by name, "it clearly takes inspiration from it" (Zhang, 2016).

At least 30 of the largest food and beverage companies in the United States have pledged to use the SmartLabel platform to provide detailed information about their products (GMA, 2015a). Moreover, the GMA projects that by the end of 2020, more than 60,000 food, beverage, personal care, pet care, and household products will have an associated SmartLabel, representing more than 80% of the products purchased in these categories (GMA, 2015a; Kvidahl, 2016).

Each SmartLabel product has its own QR code and is associated with a specific landing page on the SmartLabel.org website (Kvidahl, 2016). The design of the landing page is consistent across food and beverage products and includes a picture, links to the producer's website, and a series of tabs corresponding to the product's ingredients, nutrition information, and the presence of potential allergens. Under a tab marked 'other information,' companies also have the ability to include voluntarily disclosed certifications (such as kosher and non-GMO certifications), and nutrient content, structure/function, qualified health, 'free from,' and other claims (GMA, 2015a). Currently, some companies also use the 'other information' tab to disclose voluntarily that their products include ingredients sourced from genetically engineered crops (GMA, 2015a).

In addition to scanning QR codes that link to landing pages on the SmartLabel website, consumers can access SmartLabel information through web searches, through links from the websites of participating brands or retailers, through forthcoming digital apps, or through a retailer's customer service desk (GMA, 2015b). The GMA also cites research by the Benenson Strategy Group, which purportedly found that 75% of consumers say they would be likely to use SmartLabel. The research was conducted online in November of 2015 and involved "interviews" with "a national sample" of 902 primary household food shoppers (GMA, 2015a). However, there are no published details concerning the study's sampling methodology, the sample demographics, response rates, what information about SmartLabel was provided to the participants as part of the study, or the wording of the questions posed to participants. Therefore, the generalizability of the study is difficult to assess.

Will Consumers Use QR Codes to Seek GM Disclosure Information?

Much of the criticism of the QR code/SmartLabel disclosure option has focused on the perceived likelihood that consumers will use QR codes to access GM ingredient information. Proponents are convinced that interested consumers will use QR codes, pointing out that both UPC and QR codes have become ubiquitous in the food retail industry (Atkinson, 2013; Weightman, 2015) and so should be familiar to the public. For example, shoppers have long been able to use UPC and other barcodes to find price and product information, to redeem coupons, and to process their purchases for payment using self-checkout terminals in stores (Basker, 2012; GS1 US, 2017; Weightman, 2015). QR codes are frequently used in cross-media marketing campaigns, and since 2010, consumers have been able to use their smartphones to scan QR codes to retrieve information about products and to receive direct incentives to purchase them, including discount coupons, recipes, product sample offers, music, game, and software downloads and access codes (Okazaki, Li, & Hirose, 2012; Shin, Jung, & Chang, 2012).

Proponents also point out that cell phones have also become ubiquitous. Most American adults (95%) now own a cell phone, and more than three quarters (77%) own a smartphone capable of accessing the internet (Pew Research Center, 2018). Americans are also increasingly using their phones to make decisions about what products to buy and to purchase those products online. Half of Americans (51%) say they have used their cell phones to make an online purchase, and nearly half (45%) report having used their cellphone while inside a physical store to look up online reviews of products or to find better prices online (Smith & Anderson, 2016). Research by the Food Marketing Institute and Neilsen, suggests that nearly 60% of shoppers use their mobile devices to search for deals and coupons, and more than half of shoppers use retailers' apps when grocery shopping (Russell, 2017). This suggests that many consumers are already comfortable using their cell phones to seek information about products while shopping and therefore are likely to use them to seek information about GM ingredients if they are interested.

Critics disagree and argue that requiring consumers to scan a QR code with their phones to access GMO disclosures simply serves as a barrier to getting informa-

tion about GM foods that the public has a right to know. They contend that rather than providing greater transparency, using QR codes permits companies to hide the fact that they use GM ingredients. As such, they ridicule the new law that permits this option, calling it the Deny Americans the Right to Know (DARK) Act (Greenberg, 2016).

Opponents say that rather than using QR codes to access GM disclosure information, consumers would prefer clear on-package labeling of GMOs (O'Neil, 2016). For example, the Just Label It! campaign (Just Label It, 2015), which opposes the use of codes/SmartLabels to disclose GMO information, cites a November 2015 telephone survey of 800 likely general election voters conducted for the campaign by The Mellman Group, Inc. (2015). In that survey, participants were asked, "Would you prefer that labels indicating whether a food product at the grocery store contains genetically modified ingredients, or GMOs: 1) be printed on the package in ways visible to the naked eye OR 2) be included in bar codes on the package that could be scanned using a smartphone app?" In response, 88% reported that they favor printed labels, "visible to the naked eye."

Opponents also argue that reliance on QR codes for GMO disclosure information is "inherently discriminatory to the poor, the elderly, the rural, and minorities" because they are less likely to have smartphones able to scan them (Center for Food Safety, 2015). Recent data shows that smartphone ownership is growing significantly. More than three quarters (77%) of American adults currently have a smartphone. Yet, they are less commonly owned by African-Americans (72%), rural residents (67%), those making less than $30,000 (64%), and those 65 or older (42%; Pew Research Center, 2018).

Recognizing that not all consumers currently have smartphones capable of scanning QR codes, a provision of the National Bioengineered Food Disclosure Standard of 2016 requires the USDA to assess, "the costs and benefits of installing in retail stores electronic or digital link scanners or other evolving technology that provide bioengineering disclosure information" (National Bioengineered Food Disclosure Standard, 2016, §293 [c][3][E]). This suggests that retail food stores might eventually be required to install QR code scanners for the convenience of their customers who do not own an internet-capable smartphone.

The Environmental Working Group (EWG)—which also opposes the QR code option for GMO disclosure—claims that people are unfamiliar with the codes, and that "consumers won't know to scan" QR codes to get more information about their food (Kustin, 2015). They cite The Mellman Group, Inc. (2015) study of likely voters, which reported that only 17% said that they have ever scanned a barcode to get information, and that only 16% claim to have ever scanned a QR code. Consequently, the EWG implies that because consumers *have not* used QR codes in the past, they *will not* scan QR codes to obtain GM ingredient information in the future.

Other groups, such as the Organic Consumers Association (OCA) suggest that consumers *should not* scan QR codes for GM ingredient disclosure. Instead, they urge consumers to "boycott any company that uses the GMA's SmartLabel QR code—what we call the 'Mark of Monsanto'—on their products" (OCA, 2017a). Interestingly, in support of their "buy organic brands that support your right to know" campaign, the OCA also urges consumers to download its buycott.com mobile phone app. They suggest that consumers should "then take your mobile phone with you to the store and use the app to scan the barcode on products before you buy them. The app will look up the product, determine what brand it belongs to, and figure out what company owns that brand. Then it will cross-check the product owners against the companies and brands included in our 'Right to Know' campaign" (OCA, 2017b). The app also lists reasons to buy and reasons to avoid the product.[1]

Crucially, the advocacy organizations opposed to the use of QR codes to access GM ingredient information are also opposed to the production and use of GMOs in general, often suggesting that they have negative effects on the health of humans and the environment. As such, they urge consumers to avoid consuming products containing GM ingredients, both as a measure to protect the health of individuals and as an economic force designed to reduce the market for GM foods overall. Implicit in their opposition to disclosure through QR codes is that it makes it more difficult for consumers to reject products containing GM ingredients. Thus, disclosure through QR codes is considered an inadequate warning that a product contains GM ingredients, which they view as a necessary first step in the process of precaution adoption, in which they believe all consumers should want to engage.

1. *http://buycott.com*

Consumer Interest and Motivation

While proponents and opponents disagree over whether consumers can, will, or should use QR codes on packages to check for GM ingredients in products, their arguments typically assume a level of consumer interest in the information and motivation to seek it that may not exist. Opponents of mandatory labeling have suggested that because the GMOs currently on the market are as safe to eat as conventionally produced varieties of the same crops, *few* consumers should be interested in knowing whether the products they buy have GM ingredients. In contrast, many proponents of mandatory labeling have suggested that GMOs pose potential risks to public health and the environment, so *every* consumer should be interested in knowing whether the products they buy have GM ingredients.

Surveys do show that the majority of Americans say they support mandatory labeling of GMOs, with some polls suggesting that as many as nine-in-ten Americans support it (Anderson, 2015; Center for Food Safety, 2017; Kopicki, 2013). However, the results of these surveys may overestimate the level of support for mandatory labeling because of biases inherent in the way the questions were posed. The problem is that consumers are likely to give positive responses to direct questions asking whether they would like more information about almost any topic. For example, McFadden and Lusk (2016) found that when asked the forced-choice question, "do you support or oppose mandatory labeling for food containing GM ingredients," 84% of their participants indicated support, while 16% were opposed. However, 80% also indicated that they supported mandatory labels indicating whether foods contained DNA, a policy which would require nearly all food products in the market to be labeled as such.

Hallman et al. (2013) have also shown that the number of people who express support for GM labeling depends on how you ask the question. They found that 82% of Americans say they sometimes, frequently, or always read food labels, suggesting that most consumers are familiar with the contents of those labels. Yet, when asked in an open-ended question to *list* what information they would like to have on food labels that is not already available, only 7% of the participants volunteered that they wanted to see information about GM ingredients; about the same percentage of participants (6%) who indicated that they wanted information about the food's country of origin. Later, in the same survey, participants *rated* how important it was to have various kinds of information on food labels. In response, 59% said that it was very or extremely important to have information about whether the product contains GM ingredients on a label. This is about the same percentage who indicated that it was very or extremely important to have information about whether the product was produced using hormones (63%), pesticides (62%), or antibiotics (61%); whether it was grown or raised in the United States (60%); and whether the product contains allergens (59%). Finally, when asked directly whether GM foods should be required to be labeled, 74% responded affirmatively, 8% said no, and 18% were not sure.

All of this suggests that while most consumers may not be *opposed* to the mandatory labeling of GM ingredients, far fewer may be motivated to seek the information printed on those labels or to use QR codes to access information about GM ingredients on a website. Thus, we propose

> Hypothesis 1 (H1): More individuals are likely to report that they support mandatory labeling of products with GM ingredients than say they will use a QR code to seek GMO disclosure information.

The question is who *is* likely to use QR codes to seek information about the GM ingredients in foods. Most theories of information seeking suggest that people are most motivated to look for information when they perceive that information to be both relevant and useful to them (Case & Given, 2016). Those who perceive GMOs to be risky and presumably have intentions to avoid purchasing food products with GM ingredients are perhaps most likely to find GM disclosure information relevant and useful. Consistent with this, those who consider GM foods unsafe report checking for GM food labels more often (Pew Research Center, 2015). Thus, we posit

> Hypothesis 2 (H2): Individuals who perceive GMOs to be risky and are less inclined to buy products with GM ingredients are more likely to use UPC or QR codes to check for GMO disclosure information.

In addition to the perceived usefulness and relevance of the information, familiarity with, and the perceived ease of use of UPC or QR codes are also likely to influence the intentions of consumers to seek information about GM ingredients using QR codes (Chaffee, 1986; Shin et al., 2012). Thus, we propose

Hypothesis 3 (H3): Individuals who say that they already use UPC or QR codes for other purposes are more likely to report that they will use these codes to check for GMO disclosure information.

Methods

Data Collection

Data were collected as part of a national, dual-frame bilingual (English and Spanish) Omnibus telephone survey conducted by the research firm SSRS. Participants were recruited using random digit dialing (including both landlines and cell phones). A total of 1,011 participants, who consented to participate in the study, were interviewed between July 21 and 25, 2016, after the final version of the labeling bill was passed by the House of Representatives on July 14, and just prior to its signature into law by President Obama on July 29th. The study was part of the Annenberg Science Knowledge survey conducted for the Annenberg Public Policy Center of the University of Pennsylvania and the Department of Human Ecology at Rutgers University by the research firm SSRS, which has a margin of error of ±3.7 percentage points.

Weighting adjustments were applied to the sample to calculate descriptive statistics appropriately projected to the US population. To weight the sample, two adjustments were calculated for each case: (i) an adjustment for probability of selection (sample-weight) and (ii) a post-stratification adjustment. The sample weight was calculated as the inverse of the probability of a participant being selected into the sample. The probability of being selected into the sample is based on the participant's probability of being selected into the landline frame and the cell phone frame. As part of the post-stratification adjustment, with the sample weight applied, the 'raking' method was used to repeatedly weight the data to make the demographic makeup of the weighted sample match that of the population parameters. The March supplement of the US Census Bureau's Population Survey (2015) was used to calculate the population parameters for age by sex, race, education, marital status, and census region. The post-stratification adjustment also accounts for population density and phone status, using the National Health Interview Survey's estimate for the second half of 2015. All inferential statistics were calculated using the unweighted sample.

Measures

To assess GMO perceptions, participants were asked to respond on a 5-point Likert scale (1=strongly disagree to 5=strongly agree) their level of agreement with the following statements: "GMOs are beneficial for society," "GMOs are risky for society," and "GMOs on the market in the United States are as safe as the conventionally grown varieties of the same crops." To measure their awareness of GMOs, participants were asked to respond to the following statement: "In the last week, how much, if any, genetically engineered or modified food do you think you ate" using a Likert scale (1=a great deal, 2=some, 3=not much, 4=none at all, or 8=do not know). To gauge awareness that the current scientific consensus concerning GM crops is that they are as safe as their conventionally grown counterparts, participants were asked to indicate which of the following three statements was most accurate: 1) "Most scientists believe that genetically modified foods on the market in the United States are as safe as the conventionally grown varieties of the same crop;" 2) "Most scientists believe that genetically modified foods on the market in the United States are NOT as safe as the conventionally grown varieties of the same crop;" and 3) "Scientists are equally divided about whether genetically modified foods on the market in the United States are as safe as the conventionally grown varieties of the same crop."

To evaluate awareness that disclosure labels are not currently required on GM foods, participants were asked, "are foods that contain genetically modified ingredients required by law to be labeled as such in the United States, or are you not sure?" on a scale (where 1=yes, 2=no, 3=or are you not sure). At the time of the survey, the GM labeling bill was not yet signed into law, and the labeling requirements resulting from National Bioengineered Food Disclosure Standard of 2016 are unlikely to go into effect prior to July 2018. Therefore, participants who responded "no" to this question were recorded as being correct and "aware that GM labeling is not currently required." To assess the approval of the GM labeling bill, participants were told that, "Congress recently passed a bill that would require labeling of genetically modified foods," and were then asked, "how much do you approve or disapprove of a requirement to label genetically modified foods?" on a 5-point Likert scale (1=strongly approve to 5=strongly disapprove).

To gauge their current use of UPC or QR codes, the participants were reminded that, "Products, price tags, and coupons often include UPC or QR codes that can be scanned to get information about a product." They were

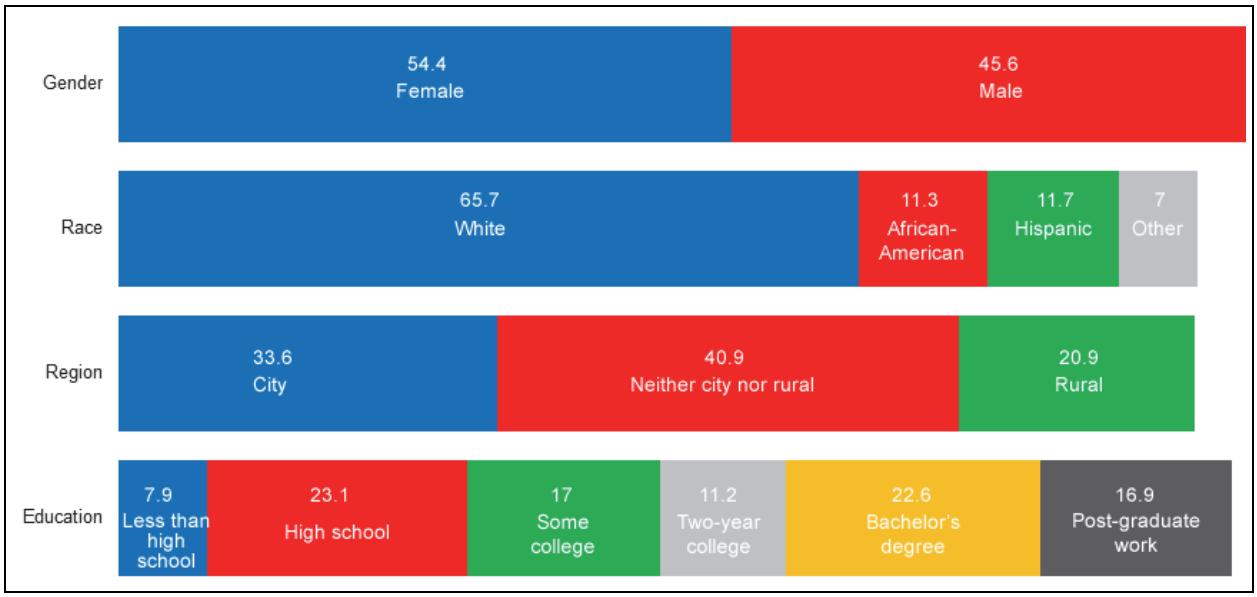

Figure 2. Demographics.
Note: Percentages represented.

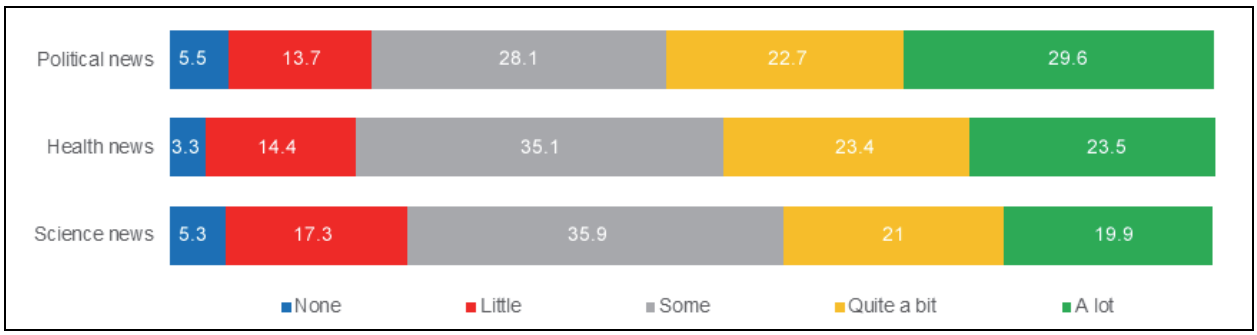

Figure 3. Amount of attention to news.
Note: Percentages represented.

then asked, "in the last 12 months, have you used your mobile phone or a store scanner to scan one of these codes to find the price of a product or to check out at a store?" and "in the last 12 months, have you used your mobile phone or a store scanner to scan one of these codes to find information about a product's ingredients or nutrition information about a product?" A variable 'using UPC or QR codes in general' was calculated by taking the mean value of these two questions.

To evaluate participants' intentions to buy products with GM ingredients, they were asked, "if you learned that a food product contained genetically modified ingredients, would you be more likely to purchase that food product, less likely to purchase it, or would it make no difference in your purchase decision?" on a 5-point Likert scale (1=much more likely to 5=much less likely). Finally, to assess participants' intentions to use their mobile or store scanner to check for GM ingredients, they were asked, "in general, how likely, if at all, would you be to use your mobile phone or an in-store scanner to find out whether a product contained genetically modified ingredients?" on a 4-point scale (1=very likely to 4=not likely at all).

Results

Mean age of the participants was 53.03 (SD=19.98). Nine-in-ten participants (90.1%) indicated that either they or someone in their household had a working cellphone. This is consistent with data from the recent Pew Research Center's report (Smith, 2017) that 95% of American adults own a cell phone. Other sample demographic information is depicted in Figures 2 and 3.

Table 1. Perceptions, awareness, and opinions concerning GMOs and the GMO labeling bill.

Variables	N*	Min	Max	M	SD
GMOs as beneficial to society	1,006	1.00	5.00	2.941	1.255
GMOs as risky to society	1,006	1.00	5.00	3.198	1.262
GMOs are as safe as conventionally grown crops	1,009	1.00	5.00	2.775	1.268
Use of UPC/QR code to check for prices	1,011	0.00	1.00	0.288	0.453
Use of UPC/QR code to check for nutrition	1,011	0.00	1.00	0.146	0.353
Awareness of GMOs in diet	1,008	0.00	1.00	0.507	0.500
Awareness of scientific consensus of GMOs	1,011	0.00	1.00	0.283	0.451
Aware that GM labeling is not currently required	1,007	0.00	1.00	0.183	0.387
Approval of GMO labeling law	1,009	1.00	5.00	4.326	1.128
Likelihood of buying products with GM ingredients	1,002	1.00	4.00	2.259	1.031
Likelihood of using QR codes to check for GM ingredients	988	1.00	5.00	2.163	1.101
Valid N (listwise)	969				

**Data are weighted to project to the population of US adult consumers.*

Public Perceptions, Intentions, and Behaviors (Weighted)

Table 1 presents the weighted descriptive statistics of perceptions, awareness, and opinions on GMOs and the GMO labeling bill. About equal percentages of US adults agree that GMOs are beneficial to society (40%) and that GMOs are risky to society (41%). However, only 30% agree that GM foods on the market in the United States are as safe as conventionally grown varieties of the same crop. Similarly, only 28% report that most scientists believe that GM foods on the market in the United States are as safe as the conventionally grown varieties of the same crop. Only half of US adults (51%) believe that they have consumed *any* GM food in the past week and 51% say they would be less likely to purchase a food product containing GM ingredients. However, only 18% are aware that GM labeling is not currently required in the United States.

Nearly three-in-ten US adults (29%) used their mobile phone or a store scanner to find the price of a product or to check out at a store during the prior 12 months. Only about half that number (15%) said that they had used their mobile phone or a store scanner to find information about a product's ingredients or nutritional information about a product. Among those who used their mobile phone or store scanner, two-in-ten US adults (22%) used them for both, i.e., to (a) find the price of a product or to check out at a store and (b) to find the information about a product's ingredients or nutritional information about a product. Four-in-ten US adults (40%) reported that they would be likely to use their mobile phone or an in-store scanner to find out whether a product contains GM ingredients.

Hypothesis 1 was confirmed. While eight-in-ten (81%) Americans say they either somewhat approve or strongly approve of a bill passed by Congress that would require labeling GM foods, only four-in-ten (40%) say they would be somewhat likely or very likely to use their mobile phone or an in-store scanner to find out whether a product contains GM ingredients. Moreover, about one-third (34%) of US adults say they strongly approve of a bill passed by Congress that would require labeling GM foods but also say they are either 'not too likely' or 'not at all likely' to use their mobile phone or in-store scanner to find out whether a product contains GM ingredients.

Who is Using UPC/QR Codes? (Unweighted)

Logistic regressions were conducted to create profiles of those who reported having used UPC or QR codes in the past 12 months to 1) find the price of a product or to check out at a store and 2) find information about a product's ingredients or nutrition information about a product. The regression models were both significant (as shown in Table 2): 1) the use of UPC or QR codes to find the price of a product or to check out at a store, ($\chi^2(8)=34.378$, $p<0.001$, Nagelkerke $R^2=0.049$), and 2) the use of QR codes to find information about a product's ingredients or nutrition information about a product, ($\chi^2(8)=31.166$, $p<0.001$, Nagelkerke $R^2=0.055$). The R^2 for both models are small but significant. Those who reported having used UPC or QR codes to find the

Table 2. Logistic regressions of using QR codes in general.

	Using UPC/QR code to check for price		Using UPC/QR code to check for nutrition	
Predictor	**B**	**SE**	**B**	**SE**
Age	-0.017***	0.004	-0.018***	0.005
Female	0.315*	0.147	0.205	0.184
Race: White	0.095	0.242	0.178	0.314
Race: African-American	0.267	0.307	0.277	0.394
Race: Hispanic	0.369	0.307	0.489	0.384
Education	0.092***	0.025	0.097**	0.031
Region: Rural	-0.062	0.182	0.091	0.229
Access to a cell phone	-0.343	0.258	0.657	0.446
Constant	-1.355*	0.532	-3.178***	0.737
Chi square	34.378		31.166	
df	8		8	
Nagelkerke R^2	0.049		0.055	
N	972		972	

*Note: ***p<0.001; **p<0.01, *p<0.05*

price of a product or to check out at a store in the previous 12 months were more likely to be younger (β=-0.017, p<0.001), have greater levels of education (β=0.092, p<0.001), and to be female (β=0.315, p<0.05). Similarly, those who reported having used UPC or QR codes to find information about a product's ingredients or nutrition information in the previous 12 months were more likely to be younger (β=-0.018, p<0.001), and to have greater levels of education (β=0.097, p<0.01). However, sex was not a significant predictor.

Strongly Approve, but Unlikely to Act (Unweighted)

About 16% of the sample (160 participants) say that they 1) strongly approve of the GMO labeling bill, 2) perceive GMOs to be risky, and yet also 3) report being "not too likely" or "very unlikely" to use QR codes to check for GM ingredients in products. A logistic regression was performed ($\chi^2(13)=67.489$, p<0.001, Nagelkerke $R^2=0.118$) to predict the characteristics of these individuals (see Table 3). Consistent with their view that GMOs are risky, these participants report that they are less likely to buy products with GM ingredients (Wald criterion=35.953, p<0.001), and consistent with a lower reported likelihood to use QR codes to check for GM ingredients, the regression indicates that these individuals were less likely to have used UPC or QR codes in general during the prior 12 months (Wald criterion=15.544, p<0.001).

Predicting Intentions to Purchase Food Products with GM Ingredients and Intentions to Seek Information about GM Ingredients Using QR Codes (Unweighted)

Two linear regressions were conducted to assess predictors of participant's self-reported likelihood to purchase food products with GM ingredients and to assess their self-reported likelihood for using mobile phones or in-store scanners (i.e., QR codes) to check for GM ingredients in products. Table 4 indicates the final blocks for both regression models.

In the first linear regression model, predictor variables were added in four blocks to assess their contribution to self-reported likelihood of purchasing food products with GM ingredients. In the first block, demographic and descriptive variables were added—age; sex coded for female; race coded for White, African-American, and Hispanic; education level; rural regions; and variables measuring participants' attention to news focused on political issues, health issues, and science issues (R^2: 0.045, adjusted R^2: 0.034). In the second block, perceptions of GMOs (GMOs are beneficial; risky; as safe as conventional varieties of crops) were added (R^2: 0.342, adjusted R^2: 0.333). In the third block, variables pertaining to awareness of GMOs were also added: how much, if any, genetically engineered or modified food the participant thought they had consumed in the prior week, and their awareness of the scientific consensus on GMOs being as safe as conventionally grown varieties of crops (R^2: 0.345, adjusted R^2: 0.334). In the final block, variables measur-

Table 3. Logistic regression to predict characteristics of those who strongly approved of the GMO labeling bill (1), perceived GMOs to be risky (2), but reported being not too likely or very unlikely to use QR codes to check for GM ingredients in products (3).

Blocks	Predictors	B	SE
Descriptives (Block 1)	Age	0.003	0.006
	Female	-0.010	0.192
	Race: White	0.038	0.304
	Race: African-American	-0.372	0.418
	Race: Hispanic	0.013	0.407
	Education	0.016	0.033
	Region: Rural	-0.047	0.232
	Access to a cell phone	-0.018	0.318
QR general (Block 2)	QR use in general	-1.343***	0.341
Awareness of GMOs (Block 3)	Awareness of GMOs in diet	0.015	0.197
	Awareness of scientific consensus on GMOs	-0.130	0.224
Awareness on GMOs (Block 4)	Aware that GM labeling is not currently required	0.087	0.240
Intention to purchase GMOs (Block 5)	Likelihood of buying products with GM ingredients	-0.630	0.105
	Constant	-0.540	0.732
	Chi square	67.489	0.732
	df	13	
	Nagelkerke R2	0.118	
	N	946	

*Note: ***p<0.001; **p<0.01, *p<0.05*

ing levels of awareness of GM labeling not being currently required and their levels of approval of the GM labeling bill were added (R^2: 0.357, adjusted R^2: 0.345).

Based on the first linear regression, participants who indicate being more likely to purchase food products with GM ingredients are also likely to be younger (β=-0.068, p<0.05), consider GMOs to be beneficial to society (β=0.271, p<0.001), not as risky to society (-0.121, p<0.001), and as safe as conventionally grown varieties of crops (0.218, p<0.001); they are also less aware that GM labeling is not currently required (β=-0.078, p<0.01) and are less likely to approve of the GMO labeling bill (β=-0.098, p<0.01).

In the second linear regression model, predictor variables were added in six blocks to assess the likelihood of using QR codes to check for GM ingredients in products. In the first block, demographic and descriptive variables were added—age; sex coded for female; race coded for White, African-American, and Hispanic; education level; rural region; variables measuring participants' attention to news focused on political issues, health issues, and science issues; and a variable coded for having a cellphone in the household (R^2: 0.119, Adjusted R^2: 0.108). In block two, perceptions of GMOs (GMOs are beneficial; risky; as safe as conventional varieties of crops) were added (R^2: 0.165, adjusted R^2: 0.152). In block three, variables pertaining to awareness of GMOs were also added, measuring how much GM food the participant thought they had consumed in the prior week and their awareness of the scientific consensus on GMOs being as safe as conventionally grown varieties of crops (R^2: 0.165, adjusted R^2: 0.151). In the fourth block, variables measuring their levels of awareness of GM labeling not being currently required and their levels of approval of the GM labeling bill were added (R^2: 0.184, adjusted R^2: 0.168). In the fifth block, the likelihood of purchasing food products with GM ingredients was added (R^2: 0.193, adjusted R^2: 0.176). In the final block, their general use of QR codes was added (R^2: 0.240, adjusted R^2: 0.223). Based on the second linear regression, participants who indicate being more likely to use QR codes to check for GM ingredients in products are likely to be younger (β=-0.110, p<0.01), female (β=0.106, p<0.01), to pay more attention to news focused on health issues (β=0.134, p<0.001), consider GMOs to be risky (β=0.080, p<0.05), approve of the GMO labeling bill (β=0.135, p<0.001), are less willing to purchase food products containing GM ingredients (β=-0.113, p<0.01),

Table 4. Linear regressions to predict the likelihood of buying products with GM ingredients and the likelihood of using UPC or QR codes to check for GM ingredients.

		Likelihood of buying products with GM ingredients		Likelihood of using UPC or QR codes to check for GM ingredients	
Blocks	**Predictor variables**	**B**	**SE**	**B**	**SE**
Descriptives (Block 1)	Age	-0.004*	0.002	-0.007**	0.002
	Female	-0.017	0.059	0.238**	0.070
	Race: White	0.022	0.093	-0.201	0.112
	Race: African-American	0.015	0.119	0.219	0.142
	Race: Hispanic	0.075	0.121	0.114	0.145
	Education	-0.011	0.010	-0.003	0.012
	Region: Rural	0.039	0.068	0.036	0.082
	Political news	0.015	0.025	0.047	0.030
	Health news	-0.055	0.029	0.138***	0.035
	Science news	-0.040	0.029	-0.017	0.035
	Access to a cell phone	---	---	-0.059	0.119
GMO perceptions (Block 2)	GMOs are beneficial to society	0.214***	0.028	-0.009	0.035
	GMOs are risky to society	-0.093***	0.024	0.067*	0.029
	GMOs are as safe as conventionally grown crops	0.170***	0.028	-0.044	0.034
Awareness of GMOs (Block 3)	Awareness of GMOs in diet	0.014	0.058	0.011	0.069
	Awareness of GMO scientific consensus	0.111	0.064	0.017	0.077
Awareness and opinion on GMO labeling law (Block 4)	Aware that GM labeling is not currently required	-0.202**	0.074	-0.054	0.089
	Approval of GMO labeling law	-0.090**	0.027	0.136***	0.032
Intention to purchase GMOs (Block 5)	Likelihood of buying products with GM ingredients	---		-0.124**	0.040
QR general (Block 6)	QR use in general	---		0.732***	0.098
	Constant	2.390***	0.263	1.430***	0.347
	N	927		925	
	R2 (R2adj)	0.357 (0.345)		0.240 (0.223)	

*Note: ***p<0.001; **p<0.01, *p<0.05*

and are likely to have used UPC or QR codes in general (β=0.223, p<0.001).

Figures 4 and 5 depict regression path models that present results from the two linear regressions shown in Table 4. The path analysis is used to portray the magnitude and significance of the direct and indirect relationships between the measured variables in the study. Figure 4 represents the regression path model with unstandardized coefficients as shown in Table 4 and Figure 5 shows standardized coefficients that allow for comparisons between variables to indicate strong predictors in the model. The results from the two regressions indicate that the variables measuring perception of GMOs as being risky to society, approval of the GMO labeling law, and the likelihood of purchasing products with GM ingredients are significant predictors of the likelihood of using QR codes to find out whether a product contained genetically modified ingredients, thereby confirming Hypothesis 2. Prior use of UPC/QR codes is one of its strongest predictors (as shown in Figure 5) of intended use of QR codes to find out whether a product contains genetically modified ingredients, which confirms Hypothesis 3. Along with these direct relationships, the path model also indicates the indirect relationships that affect the likelihood of using QR codes to check for GM ingredients. Awareness that GM

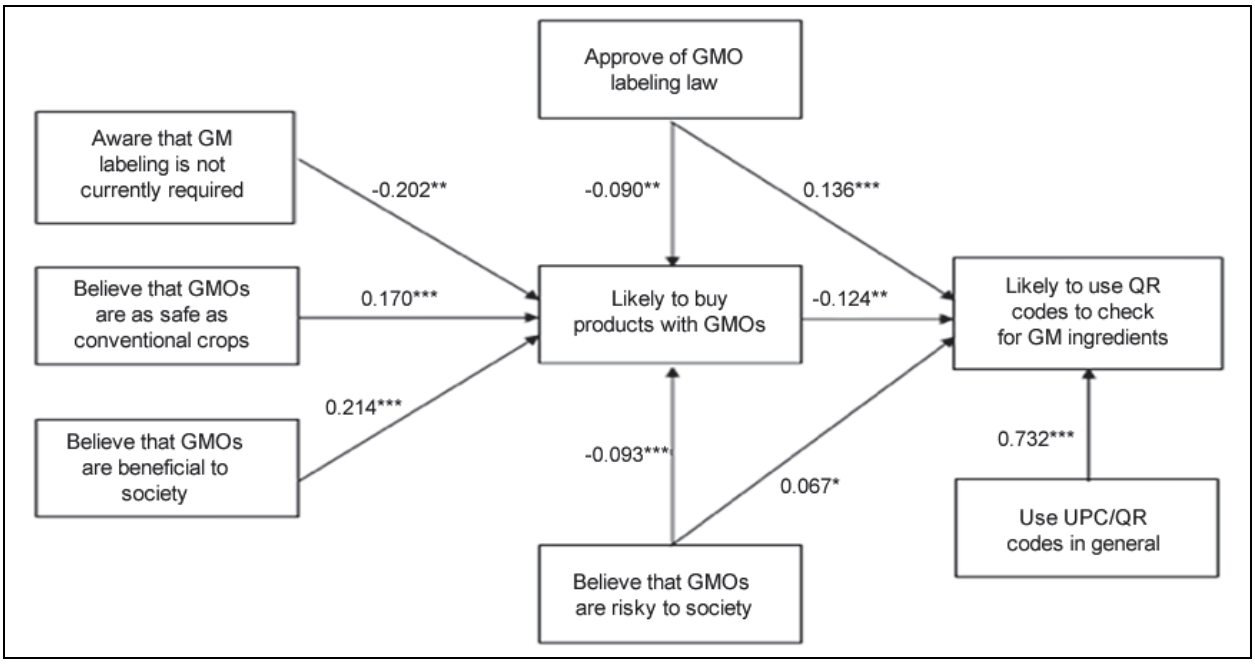

Figure 4. Regression path model (unstandardized coefficients). *Note: ***p<0.001; **p<0.01; *p<0.05*

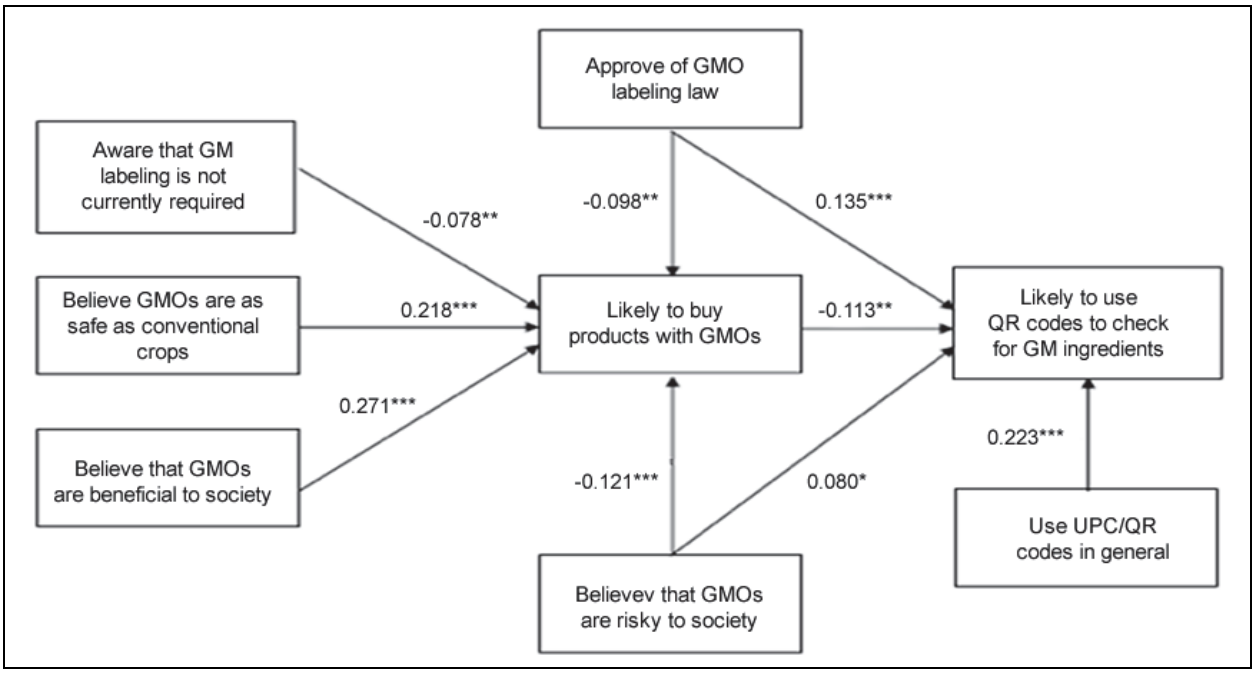

Figure 5. Regression path model (standardized coefficients). *Note: ***p<0.001; **p<0.01; *p<0.05*

labeling is not currently required, the perception that GMOs are as safe as conventional crops, belief that GMOs are beneficial to society, belief that GMOs are risky to society, and approval of the GMO labeling law are each significant predictors of the likelihood of buying products with GMOs. The regression path model depicts these direct and indirect paths that affect the likelihood of using QR codes to check for GM ingredients.

The National Bioengineered Food Disclosure Standard of 2016 mandates that foods sold in the United States that contain GM ingredients must disclose this fact. While companies are given the option to disclose the presence of GM ingredients using text or symbols on their product labels, it is likely that many food companies will opt to use a QR code linked to the SmartLabel website to make information about the GM ingredients in their products available to consumers. The fundamental question is whether consumers will use QR codes to access this information. This study suggests that the answer is yes; four-in-ten Americans say they are likely to do so. However, this number is neither as many, nor as few as might be anticipated by the proponents and opponents of mandatory labeling.

Discussion

Consistent with earlier studies (Hallman, Adelaja, Schilling, & Lang, 2002; Hallman, Hebden, Aquino, & Cuite, 2003; Hallman, Hebden, Cuite, Aquino, & Lang, 2004; Hallman et al., 2013; Kennedy & Funk, 2016; McFadden & Lusk, 2016), the results of this investigation indicate that Americans continue to have low levels of awareness and knowledge about GMOs, and many subscribe to misconceptions about them. Despite estimates by the GMA (2013) that as much as 80% of the processed foods now consumed in the United States contains one or more ingredients derived from GM crops (GMA, 2013), only half of US adults believe they have consumed *any* GM food in the past week.

The public appears equally divided with respect to whether GMOs are beneficial or risky to society overall, but much of the public appears to be skeptical about the safety of GM foods. Only about three-in-ten agree that GM foods on the market in the United States are as safe as conventionally grown varieties of the same crop. This is about the same percentage who are aware that the current scientific consensus is that GM crops and foods are safe for human health and the environment. Moreover, half of Americans say they would be less likely to purchase a product if they learned that it contains GM ingredients, though only 18% apparently know that GM labeling is not mandatory in the United States.

Consonant with other studies showing that the majority of US adults support the mandatory labeling of GM ingredients (Anderson, 2015; Center for Food Safety, 2017; Kopicki, 2013; McFadden & Lusk, 2016), the results of this investigation show that about eight-in-ten US adults say they somewhat or strongly approve of a bill passed by Congress that would require the labeling of GM foods. The National Bioengineered Food Disclosure Standard of 2016 mandates that labeling.

However, support for the mandatory labeling of GM products does not automatically translate into consumer intentions to use QR codes to check for GM ingredients. The regression analyses do show that the more likely an individual is to approve of mandatory GM food labeling, the more likely they are to say that they would use QR codes to check for GM ingredients. However, the results also indicate that about three-in-ten both strongly approve of mandatory labeling but are unlikely to scan a QR code to find out whether a product contains GM ingredients. Indeed, twice as many Americans (81%) approve of mandatory labeling as say they are somewhat or very likely to use their mobile phones or an in-store scanner to learn whether a product has GM ingredients (40%).

Not surprisingly, one of the main predictors of the future likelihood of using QR codes to check for GM ingredients is the prior use of UPC or QR codes for other purposes. However, more than half (56%) of those who say that they are very likely or somewhat likely to use QR codes to find out whether a product contains GM ingredients also reported that they had not used a UPC or QR codes in general in the 12 months prior to the survey. Thus, lack of prior use of these codes may not represent a significant barrier to their future use to obtain desired information about GM ingredients. On the other hand, 47% of those who did report using UPC or QR codes in the year prior to the survey also said that it is not too likely or not at all likely that they will use QR codes to find out whether a product contains GM ingredients. Therefore, familiarity with the use of these codes to obtain desired information (about prices or nutrition, for example) does not automatically lead to the desire to use them to find out about GM ingredients. Both of these findings are consistent with the information-seeking literature, which suggests that people are more motivated to seek information when they believe it to be relevant and useful to them (Case & Given, 2016).

Fundamentally, GM ingredient disclosure through QR codes linked to a website presents an opportunity to provide detailed, contextualized information to consumers who are motivated to seek it. When an individual scans a product's QR code and visits a SmartLabel page to find out whether the product contains GM ingredients, the information they encounter has the potential to influence their understanding or perceptions of GMOs and of the products that contain them. Indeed, scanning the QR codes of many of the products they buy might lead consumers to a greater understanding of the current

ubiquity of GM ingredients in the US food supply and in their own diets.

Yet, this study shows that those who say they are likely to seek GMO disclosure information through QR codes are not a representative cross-section of American consumers with neutral views of GMOs. Instead, the results show that those more likely to use QR codes to check for GM ingredients are people who believe that GMOs are risky to society and those who say they are less likely to buy products with GMOs. This suggests that they are more likely to seek disclosure information as a way to *avoid* GMOs, rather than as a way to improve their *understanding* of them (Dunwoody & Griffin, 2015).

Conclusions

The National Bioengineered Food Disclosure Standard of 2016 mandates that foods sold in the United States that contain GM ingredients must disclose this fact. While companies are given the option to disclose the presence of GM ingredients using text or symbols on their product labels, it is likely that many food companies will opt to use a QR code linked to the SmartLabel website to make information about the GM ingredients in their products available to consumers. The fundamental question is whether consumers will use QR codes to access this information. This study suggests that the answer is yes; four-in-ten Americans say they are likely to do so. However, this number is neither as many—nor as few—as might be anticipated by the proponents and opponents of mandatory labeling.

In fact, far more Americans indicate support for the mandatory labeling of GM foods than say they are likely to use the QR codes to check for GM ingredients. The profile of consumers most likely to do so includes those who already use UPC or QR codes for other purposes, perceive GMOs to be risky to society, and those who are less likely to purchase products with GM ingredients, suggesting that they are likely to use disclosure information to avoid such products.

Future research should investigate other factors likely to influence the use of QR codes to check for GM ingredients and the overall impact that seeking such information is likely to have on the perception, understanding, engagement, and uptake of GMOs. Given the growing support among manufacturers for using QR codes and the SmartLabel platform to disclose GM information, future studies should explore how to best present GM information, particularly to consumers who have little awareness or knowledge about GMOs and may encounter this information for the first time.

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