ANALYSES OF PEOPLE'S PERCEPTIONS TOWARD RISKS IN GENETICALLY MODIFIED ORGANISMS

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Analyses of People's Perceptions Toward Risks in Genetically Modified Organisms

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ABSTRACT

This research aims to analyze people's perceptions about the potential risks associated with the presence of genetically modified organisms (GMOs) in food products. We formulated research questions and hypotheses based on parameters, including age, gender, state of residence, and more to analyze these perceptions. We conducted an online nationwide survey across the United States and recruited participants from the general population to understand their perceptions about risks for GMOs and GM foods. We formulated a set of questions regarding the effects of GMOs on food products (including both the pre- and post-study questions) and investigated the changes in people's perceptions after reading selected news releases about GMOs. The survey responses were collected and categorized according to the research parameters and statistical assessments were conducted to test the hypotheses. Additionally, we introduced a novel approach to analyze the responses by creating a mind-map framework for both the pre- and post-study responses. We found that people residing in the southern region of the United States responded more positively toward GMOs when compared to individuals residing in the northeast, west and mid-west regions. We also deduced that people's perceptions about GMOs were not significantly different from each other whether they resided in states with Republican or Democrat/non-partisan party affiliations. Further, we observed that the male participants responded more negatively compared to the female participants across the nation. We compared the results obtained from respondents in the general population to those from a group of Computer Science students at North Dakota State University who completed the same survey. We found that students considered GMOs less risky when compared to the general population. A third research study compared participants from the general population to a group of participants who were recruited from the general population. The second group didn't read the news releases that separated the survey's pre- and post-study questions. We observed that the news releases impacted the participants from the first group and, eventually, changed the individuals' perceptions about GMOs when compared to the participants from the second group who possessed no or fewer perception changes.

Keywords: Risks, Perceptions, GMOs, Pre-study, Post-study, Mind maps.

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DEDICATION

I would like to dedicate this dissertation to my lovely and beautiful wife, Mrs. Divya Gupta, and to my eight-month-old beautiful daughter, Pragya Dass, whom I will meet for the very first time upon the completion of this research. Without their unconditional love and constant support and guidance, I would not have been able to reach this far.

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CHAPTER 1. INTRODUCTION

1.1. Overview

Genetic engineering, a form of biotechnology, introduces inheritable changes into products that are made from plants and foods. The presence of these products in the marketplace raises the question about how consumers perceive them. There are several primary biotechnology applications for such products which include using chlorine for washing chickens, using growth hormones in animals and utilizing genetically modified organisms (GMOs). Among these applications, GMOs emerge as the most researched and innovative (Whitman, 2000). These organisms have altered or manipulated genetic material through a genetic-engineering process as opposed to the traditional, natural process of mating and/or recombination (Millis, 2006). There are many popular GM products that are being used for everyday lives, including corn, rice, and dairy products (Roller and Harlander, 1998).

GMOs offer some valuable benefits to the community, such as providing resistance to diseases or insects, reducing production costs, having health and medicinal benefits, and producing higher crop yields than the non-GM counterparts. Some technological advancements for GMOs are developing crops that mature faster and are stress-resistant, thereby enhancing the crops' growth in environmental conditions where they might not have otherwise flourished (Takeda and Matsouka, 2008). Another noteworthy development can be found in the field of information processing where computers are used to automate and manage record keeping for dairy production, proving to be critical for the increased average herd size and resulting in the U.S. dairy industry's growth (Thompson, 2008). In contrast to reaping the benefits of GMOs, there are some associated risks, such as the accumulation of chemicals and harmful substances in the body, and the possibility of creating so-called super bugs in response to the genetic modifications (Persley and Siedow, 1999). Additionally, there can be other common concerns surrounding GM products that pertain to regulation, labeling, environmental impact, and monopoly rights that are exercised by corporations. A recent study by computer scientists from Massachusetts Institute of Technology (MIT) has claimed that increased exposure to GMOs and poor nutrition are responsible for the increasing number of concussions (Morley and Seneff, 2014).

1.2. Motivation

The ever-increasing world of GMOs is surrounded by many concerning issues and/or controversies. In addition to risks about the long-term impacts of GMO consumption on human health, there are other inherent concerns, such as the safety assessment of biotechnological products (Thomas and Fuchs, 2002), the effects of GMOs on the environment and nature, trust and moral issues, concerns with computer ethics (Thompson, 2008) and other related fields, etc. The complexity of the issues surrounding GMOs and GM products raises questions about how we can gain access to the associations and connections that people form, motivating us to investigate the usefulness of the deployed tools to analyze these perceptions.

These perceptions can vary based on different parameters, such as gender differences, employment status, and regional locations of a particular country such as the United States. In addition to the descriptive statistical analyses for most of the research conducted to date, appropriate statistical assessments can be utilized to test the formulated hypotheses about these perceptions, thereby resulting in concrete evidence for the existence of issues/concerns revolving around GMOs. So far, no substantial research has been conducted to analyze these perceptions from a computer-science perspective by generating a network-based setup in which relevant data reside at different nodes that represent perceptions about GMOs and useful information flowing through the edges/arcs in the form of edge weights which connect the nodes that represent node associations (or edge strengths) and form a network of people's minds, or specifically, mind maps.

To the best of our knowledge, this research is the first to address this problem. It may be noted that (Beel and Langer, 2011) applied information-retrieval tasks to mind maps in order to enhance keyword-based search engines, document-recommender systems, and user-profile generation (Beel, Gipp, and Stiller, 2009). Generating these networks can help retrieve collective useful information about how people from a particular region think about GMOs, how males perceive them in comparison to females, etc. This aspect also finds applications in other computer-science domains such as text mining and semantic analysis. Moreover, the issues regarding a single category (e.g., health effects of GMOs) in the network can be visualized as a single cluster, thus each such category can be expanded to form several clusters and a dense social network can be created and analyzed (Mishra et al., 2007).

1.3. Process Design

We formulated an approach to conduct an online survey of people's perceptions across the entire United States. The survey consisted of a set of demographic questions, such as age, ethnicity, salary, etc., plus a set of pre- and post-study GMO-related questions that indicate the effects of GMOs in different domains, such as health, economics, the environment, and more (responses marked on a five-point Likert scale ranging from **Strongly Disagree** to **Strongly Agree**). We carefully chose informational material in the form of two text-only news releases, one highlighting the positive aspects of GMOs and the other focused on the negative aspects, which appeared in that order in the survey (in condensed form), separating the pre- and post-study questions. The respondents were recruited from the entire United States via the Amazon Mechanical Turk Application Programming Interface (API) (Amazon Mechanical Turk API, 2016). These respondents resided in different regions, such as the northeast, south, west and mid-west; possessed different educational backgrounds; were in different age groups; etc. Each respondent read the same informational material in the same order (positive news release before the negative news release) as it appeared in the survey. A few limitations about the described methodology's validity are elaborated in a subsequent section.

We conducted statistical assessments and generated weighted, undirected mind maps as a novel approach to analyze these perceptions (Willis and Miertschin, 2006; Beel and Langer, 2011). Mind maps generally assume two forms. One form involves an individual mind map which illustrates a specific individual's perceptions. The other form involves aggregating perceptions based on a group of individuals. For example, Figure 1 depicts a simple mind map with a single central node that is labeled GMO and multiple terms that are interlinked in the individual's mind (Willis and Miertschin, 2006; Beel and Langer, 2011). The mind map can also be extended to represent a collection of multiple interlinked terms that are associated with a single term and the connections (or associations) between the GMO as a term and the related terms. The label for a connection (or link) signifies its strength, i.e., the link (GMO, Positive) is about 94% strong as represented in Figure 1.

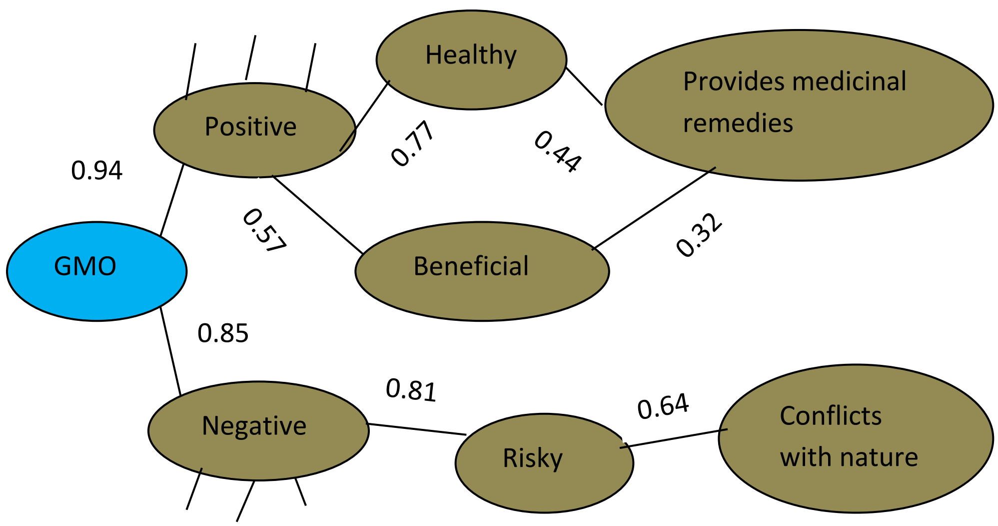

Figure 1. An example mind map

In this research, the designed survey consisted of a set of pre- and post-study questions about the effects, including the health, environmental, and ethical effects, of GMOs in food products. Each question in this category required a response based on a five-point Likert scale that ranged from **Strongly Disagree (1)** to **Strongly Agree (5)**. These questions were separated by two news releases that were read by participants before recording their responses; the design setup is discussed in more detail in Chapter 4. We conducted a Cronbach's alpha test on the questions to estimate their reliability. To analyze the participants' responses, statistical assessments and the mind-map generation process were conducted. Figure 2 presents the detailed design model for the statistical assessments.

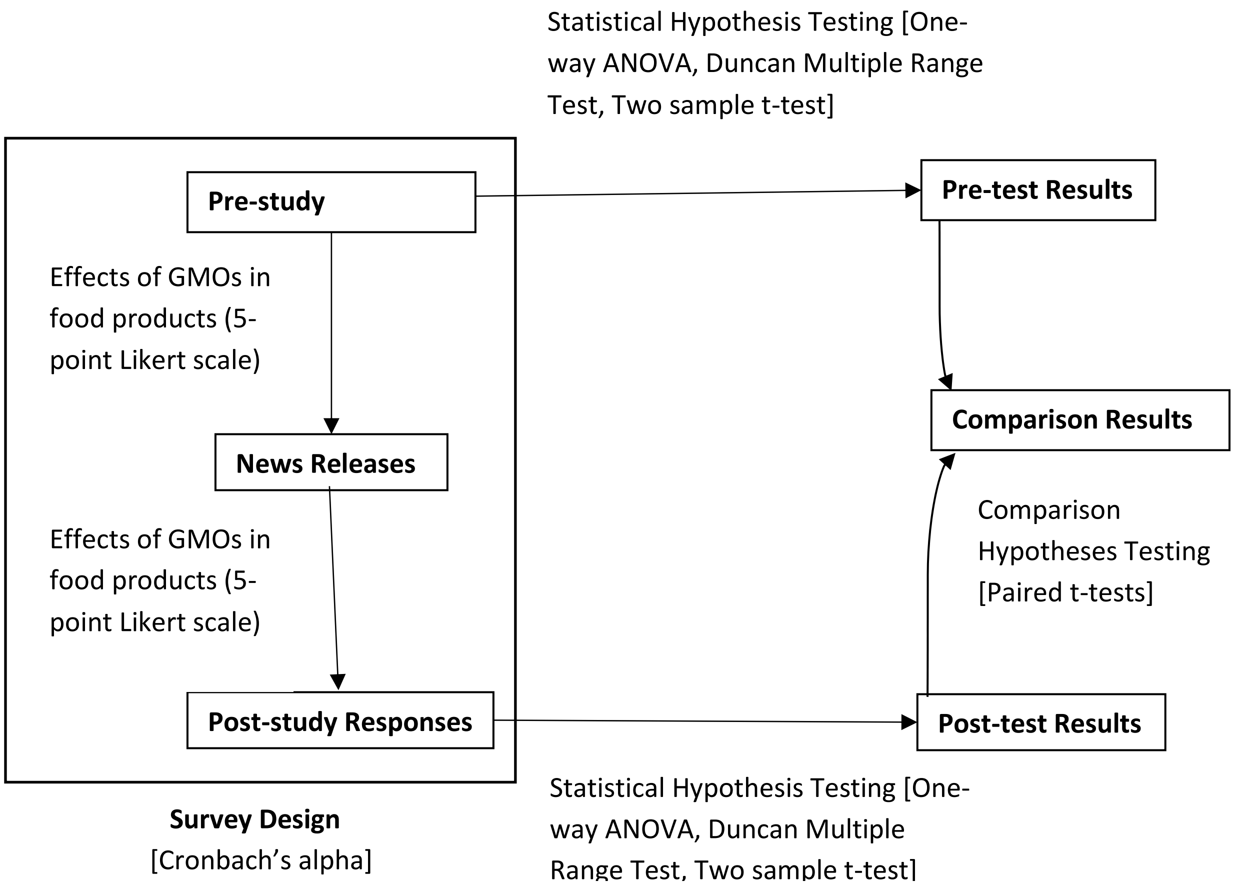

Figure 2. Design model for statistical-hypothesis testing

After collecting both the pre- and post-study responses and categorizing them according to the formulated hypotheses (discussed in further detail in Chapter 3), statistical tests, including a two sample t-test, one-way analysis of variance (ANOVA), and Duncan's Multiple Range test, were conducted to measure these hypotheses. Two sample t-tests were utilized to test two groups (i.e., male vs. female). One-way ANOVA tests were conducted to measure more than two groups (i.e., region-wise categorization). If a one-way ANOVA test was significant, Duncan's Multiple Range test was conducted as a post-hoc test to contrast all pairwise comparisons (i.e., pairwise comparisons of the mean response values for different regions) while controlling for a Type I error, i.e., rejecting the null hypothesis when it is actually true. Then, we conducted paired t-tests to compare the pre- and post-study responses in order to measure the changes in participants' perceptions as indicated in Figure 2. We provide the detailed statistical hypothesis testing in Chapter 5.

Additionally, we generated mind maps to test the same hypotheses that are formulated in Chapter 3. Figure 3 presents the design model for testing the hypotheses by using mind maps.

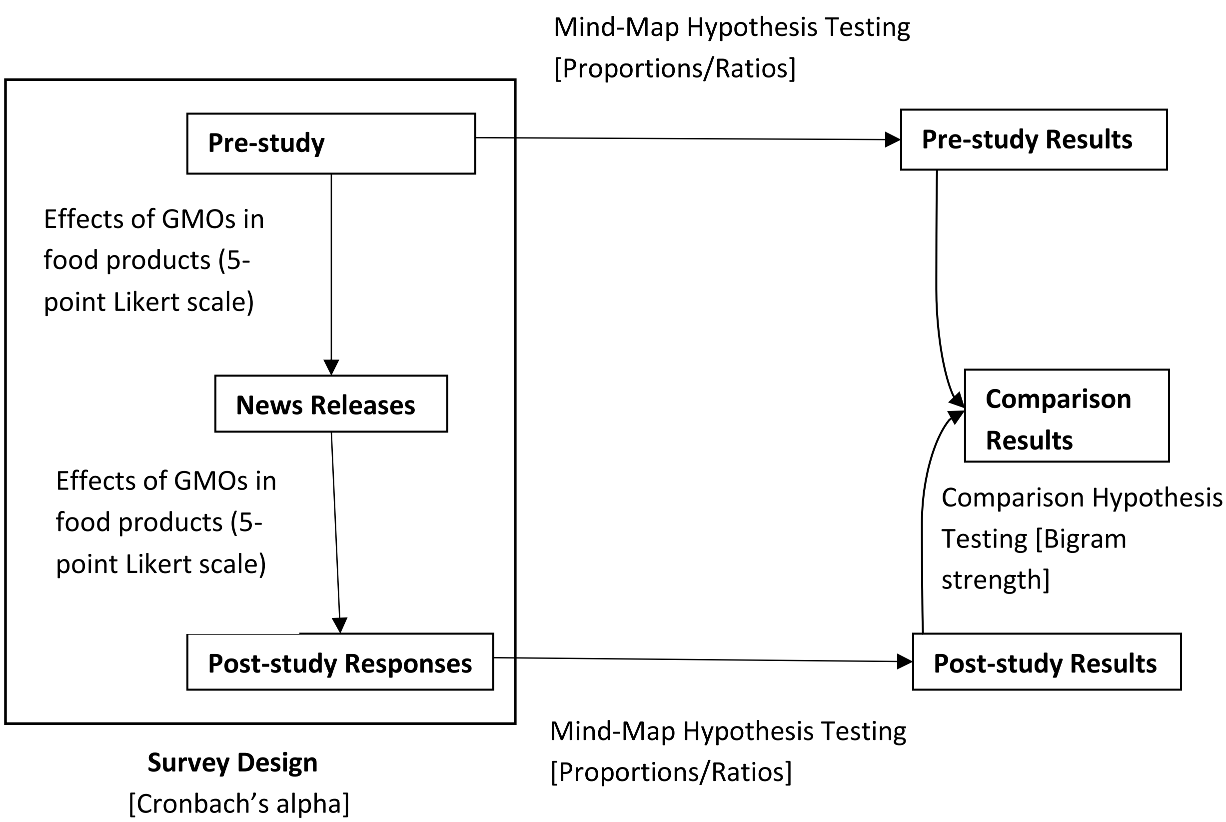

Figure 3. Design model for mind-map hypothesis testing

We tested the same set of hypotheses by generating mind maps for both the pre- and post-study responses using simple proportions/ratios as a function metric. This metric resulted in generating a weighted value (normalized within (0, 1)) for each edge (or link) on the mind map, signifying the edge's strength. We provide further details about the metric in Chapter 4. Then, both the pre- and post-study responses were compared based on the bigram (edge or link) strength. In Chapter 5, we give additional details about testing the hypotheses using mind maps.

1.4. Limitations of the Survey Methodology

We designed the survey questions in a pre- and post-study of GMO-related issues that were separated by the same news releases that respondents read in a particular order, however, reversing the order of the news releases or presenting them in different formats might yield different outcomes. It may also happen that formatting the news releases in terms of their length, font, etc. may have different influences on people's perceptions. Another aspect to examine is that the same survey completed by respondents who are part of significantly different populations gives varying responses. These responses might come from people residing in regions that are sparsely populated, states which are agriculturally aware, people with lower monthly wages as compared to individuals who reside in densely populated regions, states which are comparatively less agriculturally aware, or people who are comparatively rich. The differences in respondent populations might have occurred based on parameters such as education, age groups, etc. To the best of our knowledge, the change in observed outcomes need not pose a serious threat to the survey's validity.

1.5. Published Papers

We published two papers related to our research. Paper 1 was titled "Risk Perceptions for Genetically Modified Organisms: An Empirical Investigation." The paper's authors were Pranav Dass, Md. Chowdhury (data collection), Damian Lampl (data collection and analysis) and Dr. Kendall E. Nygard (major adviser). It was published in the proceedings of the International Symposium on Software Engineering and Applications (SEA), 2015 (Dass et al., 2015). We also presented this paper at the SEA conference held in Marina Del Rey, CA, USA, in October 2015. In this paper, we developed a novel technique to analyze people's risk perceptions about GM food products by creating mind-map networks. We divided our survey responses by participants' states of residence based on two criterions: region-wise categorization and the predominant political-party affiliation. We formulated and tested the research questions and hypotheses based on the two categorizations and then assessed the analytical results statistically. My contributions for this paper were designing the entire survey, collecting and categorizing the survey responses, generating the mind maps, and conducting the statistical assessments. Md. Chowdhury and Damian Lampl assisted with the collection of responses and then filtering and storing them. They played a supporting role in conducting the analyses pertaining to this research. Dr. Nygard supervised the research.

Paper 2 was titled "Gender Differences in Perceptions of Genetically Modified Foods." The paper's authors were Pranav Dass, Yang Lu (developer), Md. Chowdhury (data collection), Damian Lampl (data collection and analysis), Janani Kamalanathan (data collection), and Dr. Kendall E. Nygard (major adviser). It was accepted for publication in the proceedings of the 31st International Conference on Computers and their Applications (CATA), 2016 (Dass et al., 2016). The conference will be held in Las Vegas, NV, USA, in April 2016. In this paper, we compared and contrasted people's perceptions about genetically modified organisms (GMOs); the perceptions were collected from the survey responses and from extracting big Twitter data feeds. We divided both sets of responses by the participants' gender. We formulated a supervised learning approach for the survey responses, where a person's gender was known, and devised an unsupervised learning approach for the Twitter feeds, where a person's gender was unknown. We formulated and tested the research question and hypothesis based on gender and then assessed the analytical results statistically. My contributions for this paper were designing the entire survey, collecting and categorizing the survey responses, generating the mind maps, and conducting the statistical assessments. Yang Lu extracted the Twitter feeds from the streaming API and filtered the results. He also developed a procedure to determine a person's gender by using the established tools. Md. Chowdhury, Damian Lampl, and Janani Kamalanathan assisted with collecting the responses and then filtering and storing them, and they played a supporting role to conduct the analyses for this research. Dr. Nygard supervised the research.

1.6. Outline

The rest of the document is organized as follows. Chapter 2 provides a literature review that consists of two sections. The first section pertains to the prior studies concerning risk perceptions about GMOs. The second section talks about mind maps. Chapter 3 states the study's objectives along with the research questions and hypotheses. In Chapter 4, we discuss the Design Setup in detail. Chapter 5 provides the results and analyses. Chapters 6 and 7 contain the published papers. Chapter 8 provides the conclusion and the future scope for research.

CHAPTER 2. BACKGROUND AND CONTEXT

This chapter provides the background literature concerning risk perceptions about GMOs and the mind maps to evaluate these perceptions. Researchers around the world have been conducting research involving the presence of GMOs in crops and food products to measure people's perceptions about the potential risks involved with these entities (Baker and Burnham, 2001; Burton et al., 2001; Baker and Mazzocco, 2001; Burton and Pearse, 2002). These risks can be associated with ethics as seen by computer scientists (Thompson, 2008); with environmental impact (Kaempf, 2005); or with other factors, such as health, trust, and safety. As stated in (Thompson, 2008), the introduction of GMOs in Europe in the 20th century sparked a major international controversy. Later, GMOs got accepted in the United States. However, some surveys conducted about GMOs indicated some level of concern (Gaskell, Thompson, and Allum, 2002). Computing and information-technology professionals exhibit high standards of engagement with ethical issues relating to privacy and information security. There are areas such as stem-cell research, nanotechnologies, and other aspects of science where it would be difficult to go further without the computational capacity of information processing. In many instances, computer technology has been deeply involved with the issues surrounding contested technologies, most popularly GMOs.

There have been prior studies measuring risk perceptions about GMOs and GM products. One such study was carried out by (Finucane and Holup, 2005); they devised a theoretical framework to understand psychosocial and cultural factors pertaining to risk perceptions about GMOs across the United States, selected countries from Europe, and the developing world. In this study, the authors provided a framework to understand the socio-cultural differences in cognition and behavior based on the psychological, sociological, and anthropological factors for analyzing risk perceptions. This framework helped to bridge knowledge gaps about people's cultural values regarding risk perceptions for GMOs, improving the effectiveness of policy development, decision making, and risk communication about GMOs. The authors learned that a thorough and systematic assessment of cross-cultural differences for risk perceptions about GM foods helped to fill knowledge gaps, resulting in efficient decision making and effective communication. The authors also emphasized that there's an increased need to explore several determinants of risk (s) involving GM foods, such as psychological and socio-cultural factors, in order to gain a better understanding of the risk perception about GMOs and related products. (Bugbee and Loureiro, 2003) conducted a study where they evaluated people's purchasing attitudes about GM foods and designed theoretical models to address the issue. The authors developed a binary-choice model to analyze the decision of paying a premium (Willingness to Pay, WTP) or accepting compensation (Willingness to Accept, WTA) for two GM products, GM tomato and GM beef. The authors additionally developed a random utility model that utilized a probability framework to express the binary-choice model. Further, the authors formed a "probit" regression-testing model to analyze the risk perceptions associated with GM foods. The findings suggested that, the higher the premium, the lesser the likelihood that the consumer would pay for it and that a higher percentage of people preferred GM tomatoes over GM beef, thereby developing a bias for the acceptance of GM plants over GM animal products. Some similar approaches have been conducted but all of them considered a limited suite of aspects for risk perceptions, especially people's purchasing behaviors across different countries (Savadori et al., 2004; Pidgeon et al., 2005; Moon, Balasubramanian, and Rimal, 2006; Onyango, Nayga, Jr., and Govindasamy, 2006), and considered few issues, such as health, cultural, and psychosocial factors. Some survey-based approaches, which involved sending the survey by mail to selected participants in the United States, were used. This process consumed a large amount of time and resulted in low response rates. In our research, we administered the survey online, resulting in high response rates and consuming less time.

All the previous researchers mainly concentrated on theoretical modeling and applying analytical procedures, focusing on a narrow range of people's behaviors and perceptions. Our research is the first, to the best of our knowledge, in the sense that, to date, no substantial work has been done to apply a cognitive or visual approach in order to measure risk perceptions about GMOs. In this research, we introduced a mind-map based approach (Willis and Miertschin, 2006) to obtain a better understanding of how people perceive GMOs and GM products. (Jonassen, 1996) coined the phrase "Mindtool" to describe using computer technology for engaging learners to think critically. Further, (Jonassen, Carr, and Yueh, 1998) categorized the computer applications that are used as mind tools into several classes: semantic-organization tools, dynamic-modeling tools, information-interpretation tools, knowledge-construction tools, and communication and conversation tools. One of the best-known semantic-organization tools is the mind map (Jonassen, Beissner, and Yacci, 1993; Buzan, 1995).

A mind map illustrates the representation of associations between a single concept and its related terminologies that are spread uniformly over the concept. Major ideas are connected directly to the central concept, and other ideas emanate from the major ideas (“Who invented mind mapping”, 2016). Mind maps have been constructed by using established tools, such as MindMeister, for basic exploratory analyses (Beel and Langer, 2011). Mind maps have several uses for real-world scenarios such as brainstorming, organization, creativity, speed, information retrieval, and searching. However, mind maps also have some limitations, such as lack of learning intent among individuals, issues surrounding the appropriateness and effectiveness of mind maps, space issues, the choice of the relevant tool (s) to construct a mind map, etc. It is well known that people are using mind maps for several tasks that require hierarchical structuring of information, such as brainstorming, document drafting, and project planning. According to (Beel and Langer, 2011), “There was only one paper we found that is somewhat related: a survey from the Mind Mapping Software Blog (Frey, 2010). For this survey, 334 participants answered questions about their use of mind-mapping software. However, the survey was based on 334 self-selected participants from a single source. Some mind maps have been drawn using MindMeister to illustrate the risk perceptions about GMOs (“Are GMOs in Food Safe?”, 2016), but without any weight considerations and not in a published form, such as conference proceedings or a journal. Some blog posts highlight the usage of mind maps to assess GMOs as well (“Who Invented Mind Mapping?”, 2016). Based on the responses obtained from the survey data, we introduced weights to the mind-map network. Our approach dealt with evaluating word and bigram (a pair of words and phrases) strength as a measure of comparison and analysis in the mind-map network. Within the survey and the associated mind maps, we included several aspects or impact factors that pertain to the research, such as health, the environment, the economy, ethics, and trust in both the GM institutions and the government. Previous studies only considered descriptive statistical analyses but in our research, we conducted statistical hypothesis tests, in addition to the descriptive statistical analyses, to analyze the risk perceptions about GMOs.

Further, we analyzed the perceptions about GMOs for people who are socially active on Twitter; those results are included in Chapter 7. By extracting large sets of tweets (Kumar, Morstatter, and Liu, 2013), storing them in a database, parsing them, and conducting analytics on them, we obtained a basis to compare the survey and the mind-map work. There are many studies that involve extracting Twitter feeds and conducting a sentiment and/or opinion analysis based on those Twitter feeds. (O'Connor et al., 2010) devised a strategy to map a tweet's entire text as a sentiment and formulated public opinions based on those sentiments. (Agarwal and Sabharwal, 2012) focused on extracting and analyzing a single tweet and its followers, and devised a strategy to conduct a sentiment analysis. In our research, in addition to extracting a set of Twitter feeds that contain people's opinions about GMOs, we extracted useful keywords from the individual tweets and conducted analyses that were designed to understand those opinions. This approach brought novelty to our research because very few previous works had been done with dictionary formulation followed by extracting useful keywords from specific tweets in order to classify them and to carry out a sentiment or opinion analysis.

CHAPTER 3. RESEARCH PROBLEM AND OBJECTIVES

This research developed a new approach to measure the changes in a person's perceptions about the potential risks with the presence of GMOs in food products by conducting statistical assessments and generating mind maps. We proposed the following research questions and hypotheses.

Fundamental Research Question: Do people believe that GM foods are risky for their families?

Fundamental Hypothesis: Pre-conceived perceptions about GM foods' risks influence people to avoid them.

Research Question 1: Do people change their prior perceptions about GMOs?

a. Does reading news releases influence people's perceptions?

b. Does prior knowledge about GMOs influence people's perceptions?

Hypothesis 1: Reading the news releases influences people to respond positively toward GMOs.

Hypothesis 2: Prior knowledge about GMOs does not affect people's perceptions about GMOs after reading the news releases.

Research Question 2: Do demographics (state of residence, gender, number of children, age, employment status, marital status, education level, and ethnic background) play a role in forming people's perceptions about GMOs?

Hypothesis 1a: People residing in the *southern* region of the USA respond more positively to GMOs than individuals residing in the *northeast, west, and mid-west* regions of the USA.

Hypothesis 1b: People from *Republican* states in the USA believe that GM foods are risky for their families as compared to individuals from *Democrat/non-partisan* U.S. states.

Hypothesis 2: When asked about GMOs, males tend to respond negatively about them as compared to females.

Hypothesis 3: People with fewer than three children living in their household respond positively about GMOs as compared to people with more than three children.

Hypothesis 4: People who are over 40 perceive GMOs as risky when compared to people who are under 40.

Hypothesis 5: People who are employed respond negatively toward GM foods when compared to individuals who are not employed.

Hypothesis 6: People who are married or in a domestic partnership respond positively toward GMOs when compared to others who are not married.

Hypothesis 7: People who have attained doctoral or master's degrees tend to support GMOs as compared to individuals who attained a bachelor's degree or less.

Hypothesis 8: People who are White, Black/African American, and Native American/American Indian respond positively about GM foods as compared to individuals who are Hispanic/Latino and Asian/Pacific Islander.

Research Question 3: Do people's purchasing attitudes influence their perceptions about GMOs?

Hypothesis 1: People who spend less than 25% of their salary purchasing groceries perceive GM foods as risky.

Hypothesis 2: People who purchase groceries daily or very frequently tend to support GMOs.

We present the testing results about Research Question 2 for Hypotheses 1a and 1b, and Hypothesis 2 in more detail in Chapters 6 and 7, respectively.

CHAPTER 4. DESIGN SETUP

We discuss different sections of the design in this chapter. We provide the survey design process along with information about the news releases and the survey questions' reliability estimates in detail. We also explain the detailed procedure to generate mind maps.

4.1. Survey Design

We designed a survey using the Qualtrics Survey API ("Qualtrics API", 2016) and administered it online. This survey consisted of demographic questions, such as age, ethnicity, education level, and salary, as well as a set of pre- and post-study questions that were related to GMOs and the effects of their presence in food products. We presented the questions in the form of question statements and provided a five-point Likert scale (**5**, Strongly Agree; **4**, Agree; **3**, Neutral; **2**, Disagree; and **1**, Strongly Disagree) for participants to record their responses.

In addition, the survey consisted of two text-only news releases between the pre- and post-study questions; the new releases highlighted the positive and negative aspects of GMOs. Participants read the news releases (in a condensed form) after completing the pre-study questions. The first news release described the adoption of a variety of GM crops, such as maize and soybean which were declared *safe* by the European Union (EU), with the authorizations valid for 10 years ("Commission authorises", 2015). The second news release highlighted the announcement of two Hershey's chocolate products (milk chocolate and kisses) that would be non-GMO by the end of 2015. This decision was made to support a GMO campaign that had been running for two years (“GMO inside”, 2015). After reading the news releases, participants completed the post-survey questions. The entire survey and the news releases are available in Appendices A and B, respectively.

We formulated research questions and hypotheses based on potential uncertainties or risks involving GMOs. After reading several blogs and popular news articles about GMOs, we carefully selected and formulated the survey questions by following the general ideas of the perceived controversies about GMOs. The participants did not have access to the pre-study questions once the responses were submitted. There wasn’t a timer provided to the participants when they responded to the questions. We provided a condensed form of the news releases in the survey so that the participants would not lose interest in the survey or get bored, or would not form a bias towards a news release. We did not randomize the order of the news releases while designing the survey. A participant’s response to the survey was considered as complete only when the responses for both the pre- and post-study questions were recorded. Otherwise, the response was considered as incomplete and discarded.

About 446 participants from the general population were recruited via the Amazon Mechanical Turk API (Amazon Mechanical Turk API, 2016) within the United States, and about 106 participants from the general population were recruited via the same procedure; the distinction was that they did not read the news releases between the pre- and post-study questions, thus serving as a *control group* for the first set of participants. Additionally, 69 students from the Fall 2015 CSCI 489/689 class (a computer science course) at North Dakota State University, USA, were recruited for the designed survey in order to compare and contrast with the results from the general population.

4.2. Reliability Estimation

For each set of designed survey questions (pertaining to GMOs and the various effects of their presence in food products), internal consistency was measured using Cronbach's alpha. Internal consistency is an assessment about how closely each set of questions measures the same construct and produces similar results. For example, one of the question categories in the survey assessed the participants' perceptions about the health effects of GMOs, including eight individual question statements which people responded to on a five-point Likert scale. Because all the statements within this construct addressed the same theme (health effects), one would expect a participant to respond accordingly to each item in the construct. Cronbach's alpha is a method that is used to assess this internal consistency and, thus, the correlation between the different statements in each set of questions (Cronbach, 1951). The standardized formula for Cronbach's alpha is:

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}}$$

Here, N is the total number of questions, $\bar{C}$ is the average inter-question covariance among the questions, and $\bar{V}$ equals the average variance. We can easily see that the value of alpha is directly proportional to the values for the total number of questions and the average inter-question covariance (George and Mallery, 2002). Generally, **0.7** or higher is an acceptable reliability coefficient. Table 1 provides a breakdown to describe internal consistency based on the alpha value (Nunnally, 1978). Table 2 presents the survey questions and their corresponding Cronbach's alpha values.

Table 1. Cronbach's alpha values for internal consistency

Cronbach's alpha	Internal consistency
α ≥ 0.9	Excellent
0.9 > α ≥ 0.8	Good
0.8 > α ≥ 0.7	Acceptable
0.7 > α ≥ 0.6	Questionable
0.6 > α ≥ 0.5	Poor
0.5 > α	Unacceptable

Table 2. Cronbach's alpha reliability values for the survey questions

Question	Alpha Value
In your opinion, what could be the health effects of GMOs?	0.94
In your opinion, what could be the environmental safety effects of GMO?	0.91
In your opinion, what could be the ethical factors of GMO?	0.93
In your opinion, what could be the trust factors associated with GMO biotechnology institutions?	0.88
In your opinion, what could be the trust factors associated with government institutions?	0.89

From Table 2 we can see that our designed set of survey questions has values above the standard, acceptable reliability-estimate threshold value (0.7). Therefore, we can say that these questions successfully passed the reliability tests and seemed appropriate for our research.

4.3. Mind-Map Generation

We generated *weighted, undirected mind* maps using NodeXL (Hansen, Shneiderman, and Smith, 2010) for our research. The following sections describe the process of generating these mind maps.

4.3.1. Mind maps for survey responses

We generated mind maps for both the pre- and post-study responses from the three participant groups (Amazon Mechanical Turk [general population and control group] and CSCI 489/689 students). We referred to each word as a *node* and each link connecting two nodes as an *edge*. The term *GMO* served as the root node for the mind map. Each question statement from the survey was linked to the root node. We didn't assign any weights to these edges because we were mainly interested in assigning weights to the bigrams linking a question statement with a survey-response value. This procedure resulted in generating exactly five response values for each question statement.

Each edge consisted of two nodes and the combination of these two nodes formed a *bigram* (pair of two words and/or phrases). For example, *(GMO, Provides medicinal remedies)* acted as a bigram in the mind map. A weight value for an edge signified a bigram's *importance (or strength)* to a response. To assign a relevant weight to each edge, we followed the idea of computing simple ratios (or proportions) by dividing each bigram frequency by the total number of responses. Finally, the weighted score was normalized within the interval (0, 1). Proceeding in this manner, we assigned weights to each bigram in the mind map. The weight value for each edge signifies its *strength*, resulting in calculating the ***bigram strength*** **(weight value associated with a particular bigram)** for each bigram in the mind map.

4.3.1.1. Mind maps from the general-population participants' responses

An example of a collective mind map produced using the approach described in Section 4.3.1. is given in Figure 4. This map depicts the pre-study responses for all *male* participants from the Amazon Mechanical Turk general population.

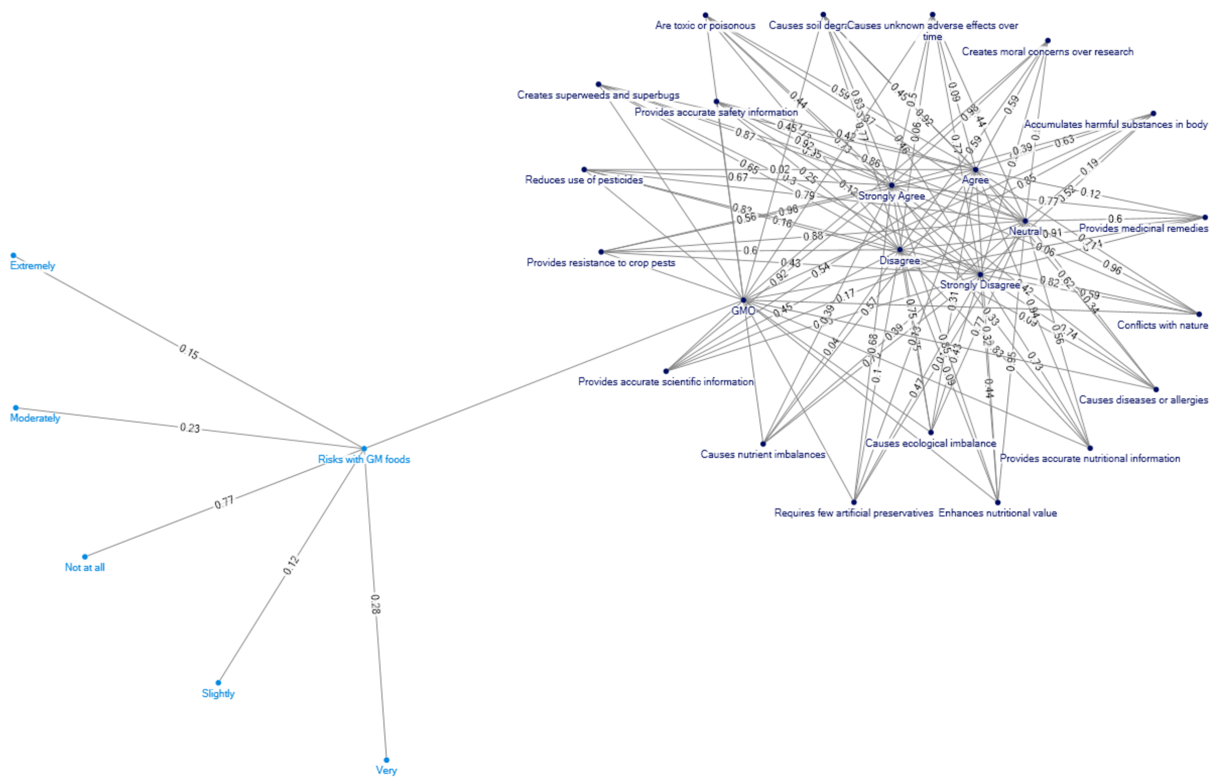

Figure 4. Pre-study collective mind map for all general-population male participants

4.3.1.2. Mind maps from the CSCI 489/689 class students

The entire collective mind-map generation process is the same as described in Section 4.3.1.1. except that the participants were recruited from the CSCI 489/689 class instead of representing the general population. An example of a collective mind map depicting the pre-study responses for all *male* participants from the CSCI 489/689 class is shown in Figure 5.

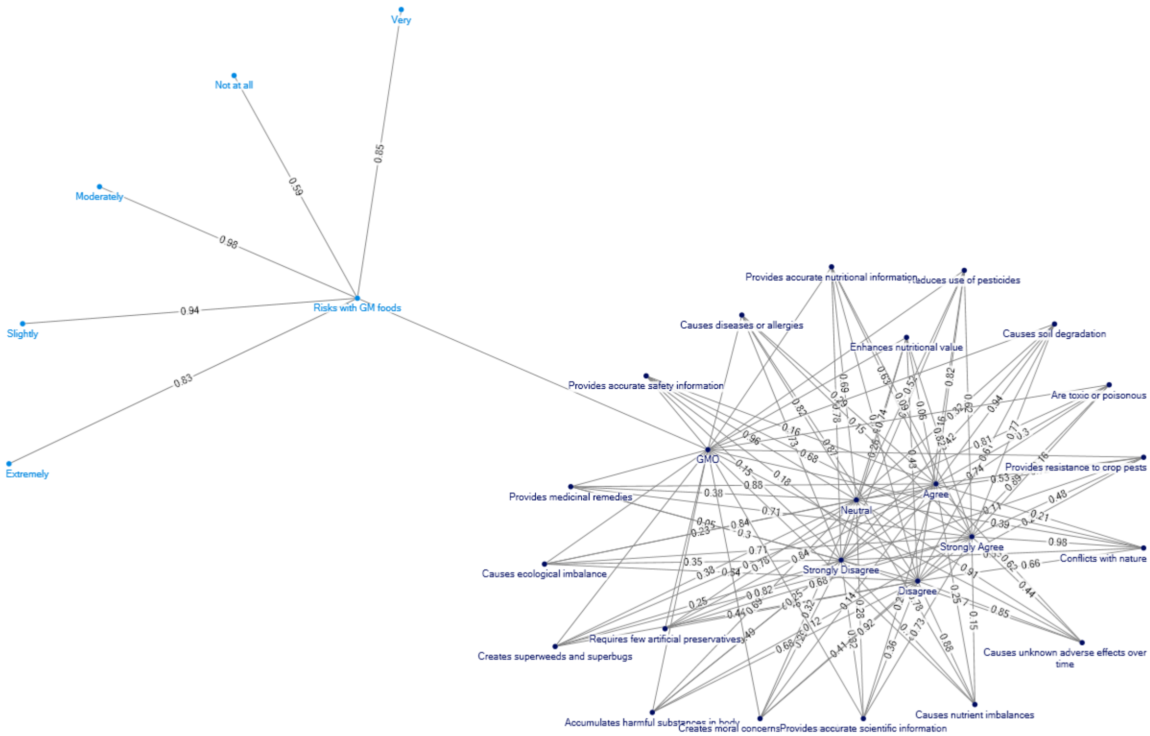

Figure 5. Pre-study collective mind map for all male-student participants

4.3.1.3. Mind maps from the control-group participants

The entire map-generation process is the same as described in Section 4.3.1.1. except that the participants represented the *control group* for the general population. The collective mind map depicting the pre-study responses for all *male* participants from the *control group* is shown in Figure 6.

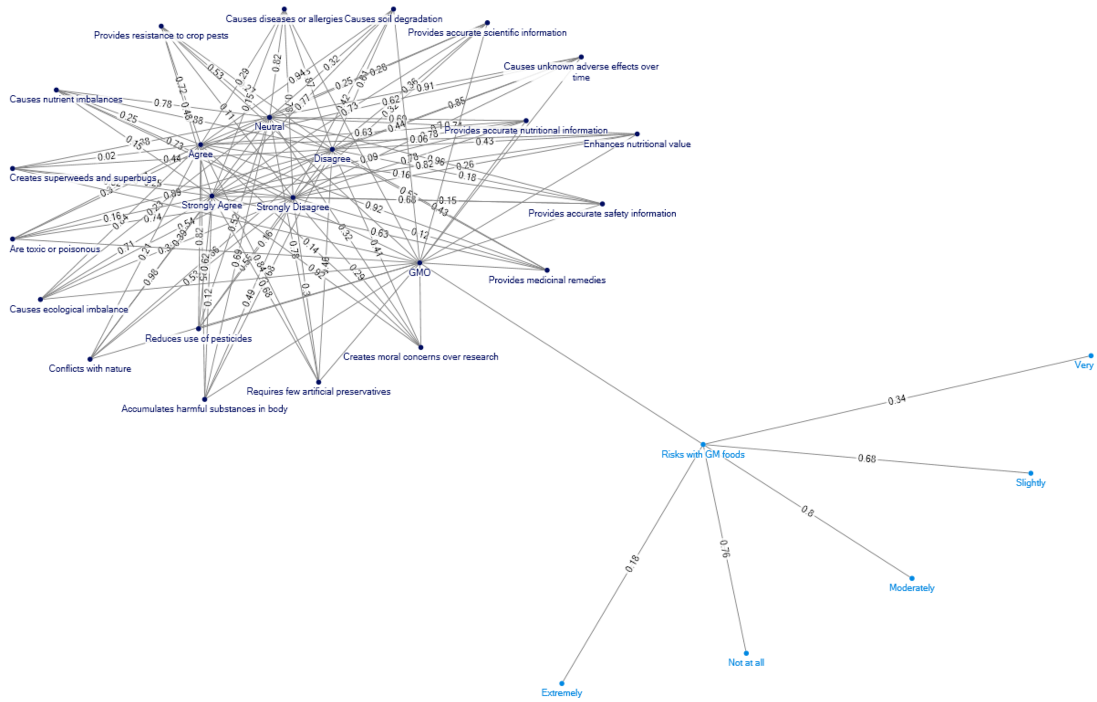

Figure 6. Pre-study collective mind map for all *control-group* male participants

For future exploration, we plan to extend the use of mind maps by applying them to other aspects, such as computing the connections and flows across a weighted network. We calculated different centrality measures for a mind-map network which can help to compute maximal flows and the shortest paths across the network. Other analysis possibilities are in the form of social-network analysis on a mind-map network which can open doors to solve many interesting problems. Another application can be to cluster the network into dense modules and to assign the concept of champion nodes to the modules. This application holds promise for data-mining and machine-learning techniques to analyze the results.

CHAPTER 5. RESULTS AND ANALYSES

This chapter provides detailed analyses of the quantitative data, including the participants' recorded responses. An alpha value of 0.05 (indicating a 95% confidence interval) was used for all statistical assessments conducted with Statistical Analysis System (SAS) version 9.3. All mind maps were created using Network Overview Discovery and Exploration for Excel (NodeXL) (Hansen, Shneiderman, and Smith, 2010) version 2014 and all the edge-weight values were normalized within the interval (0, 1). A *K* value of 2 (indicating at least a 75% confidence interval using Chebyshev's inequality [Knuth, 1997]) was used for all mind-map evaluations.

5.1. Statistical Hypothesis Testing

To test the formulated hypotheses from Chapter 3, we conducted statistical assessments. Figures 7 and 8 depict the box-plot diagrams that show the regional distributions for the pre- and post-study responses, respectively, about the health effects of GMOs. To properly depict the response variation in the box-plot diagrams, we considered the average of all eight questions pertaining to the health effects of GMOs and depicted them using a 5-point Likert scale in the box-plot diagrams for both figures. The F-statistic and the related p-value for each figure from the one-way ANOVA test are provided in the plot's top-left corner. Note that the 5-point Likert scale values are plotted in coded form on the left axis ("1" indicates the most negative perception and "5" the most positive).

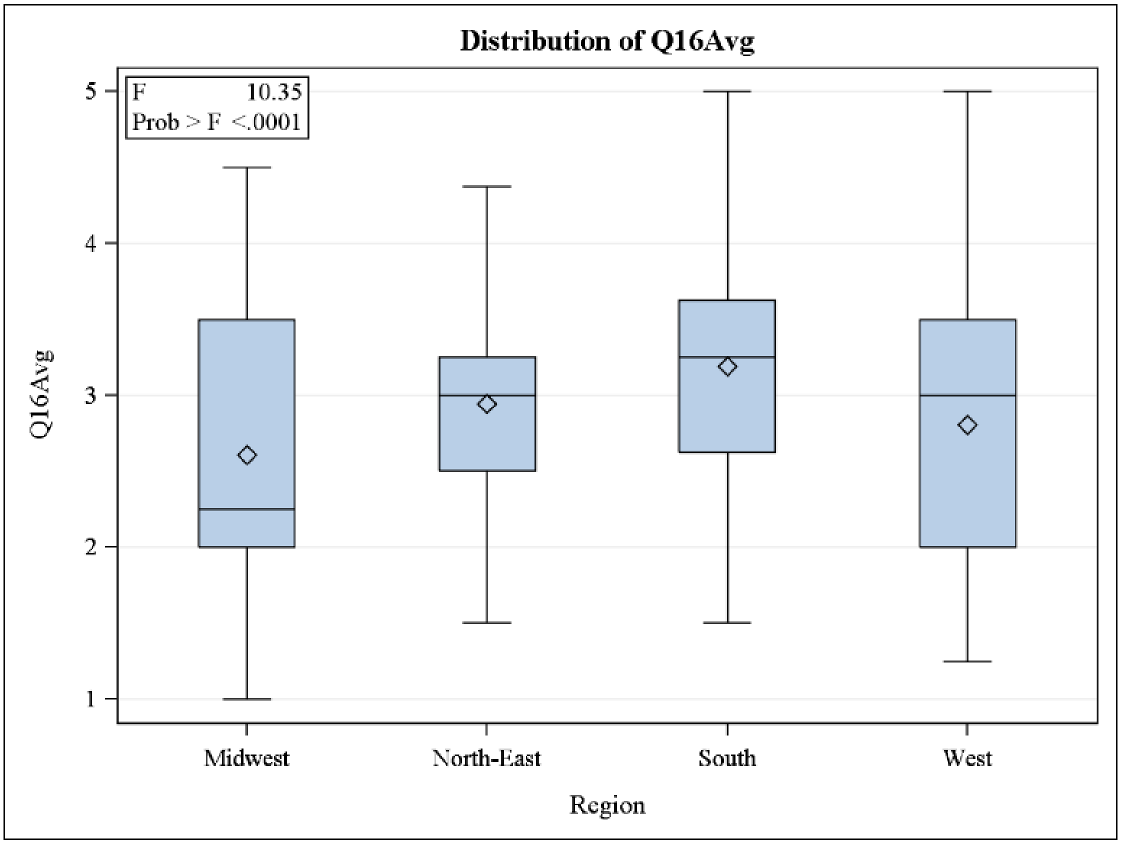

Figure 7. Pre-study box-plot distribution for the question “In your opinion, what could be the health effects of GMOs?”

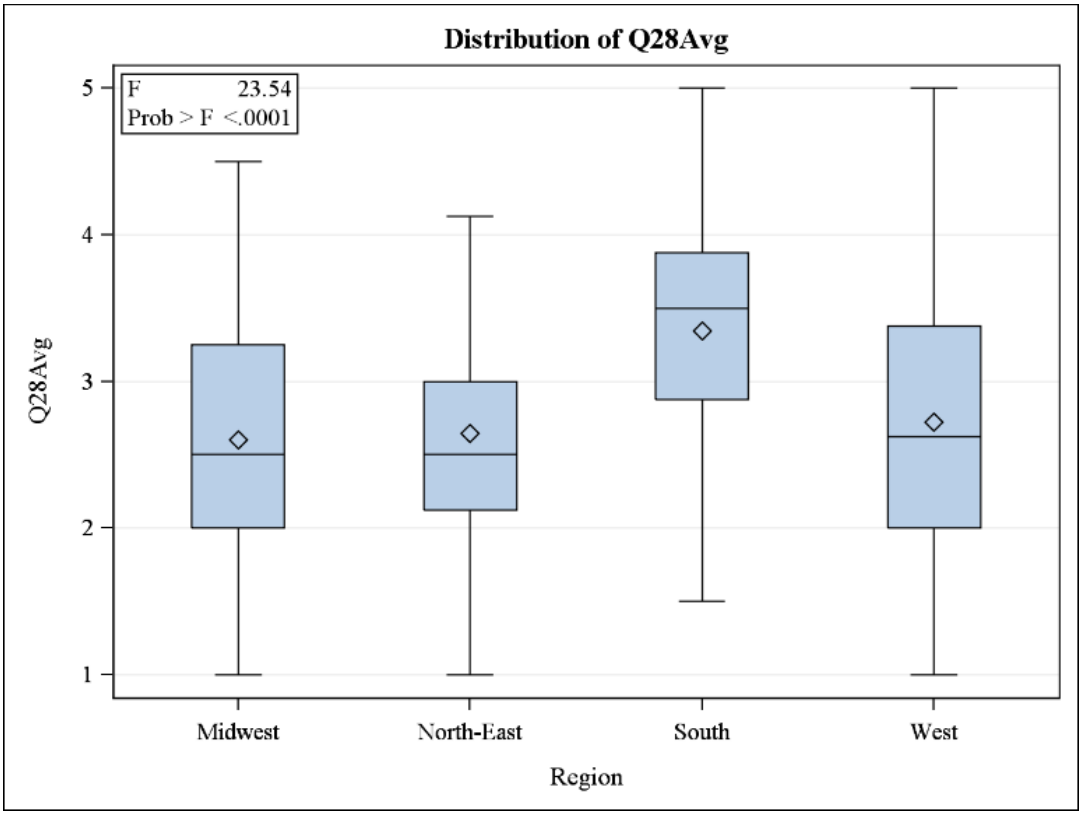

Figure 8. Post-study box-plot distribution for the question "In your opinion, what could be the health effects of GMOs?"

In these box plots, the *diamonds* represent the mean values and the lines that bisect the box represent the *median*. From these box-plot distributions, we can clearly deduce that the mean values for the *southern* region in both distributions are the highest when compared to the mean values for the other regions. The mean value in Figure 7 is 3.1895, whereas, in Figure 8, the mean has increased to 3.3452. The significant increase for the mean values is because more people have changed their responses to either *agree* or *strongly agree*. The p-values for both the pre- and post-study F-tests for the one-way ANOVA are less than 0.0001, indicating that we reject the *null hypothesis* and suggesting a significant difference in the regional means. ANOVA tests for the difference in the mean responses, however, it does not tell which means are significantly different. Therefore, Duncan's Multiple Range test was utilized to measure this difference. Figures 9 and 10 provide the Duncan groupings for the various regions along with their respective means for both the pre- and post-study responses.

Duncan Grouping	Mean	Region
A	3.1895	South
B	2.9421	Northeast
B, C	2.8043	West
C	2.6088	Midwest

Figure 9. Pre-study Duncan groupings for the question: “In your opinion, what could be the health effects of GMOs?”

Duncan Grouping	Mean	Region
A	3.3452	South
B	2.6435	Northeast
B	2.7227	West
B	2.6042	Midwest

Figure 10. Post-study Duncan grouping for the question “In your opinion, what could be the health effects of GMOs?”

It is evident from both figures that means with the same letter are not significantly different. From Figure 9, the *southern* region has an “A” grouping, the *north-east* and *western* regions have the “B” grouping, and *western* and *mid-west* regions have the “C” grouping. This indicates that mean responses from the *southern* region are significantly different than the other regions while the mean responses from the *northeast* and *western* regions are not significantly different. Also, the mean responses from the *western* and *mid-west* regions are not significantly different, but the mean responses from the *northeast* and *mid-west* regions are significantly different. Likewise, we can infer from Figure 10 that the mean responses from the *southern* region are significantly different from the other regions while the mean responses from the *northeast*, *mid-west,* and *western* regions are not significantly different. This supports our original hypothesis that people who reside in the *southern* region respond more positively about GMOs when compared to individuals who live in other regions (Hypothesis 1a for Research Question 2 from Chapter 3).

Figures 11 and 12 provide the histogram plots for the pre- and post-study responses for the question about the effects of risks with GM foods. Note that the 5-point, Likert-scale values are plotted in a coded form on the x-axis ("1" indicates the most negative perception and "5" the most positive).

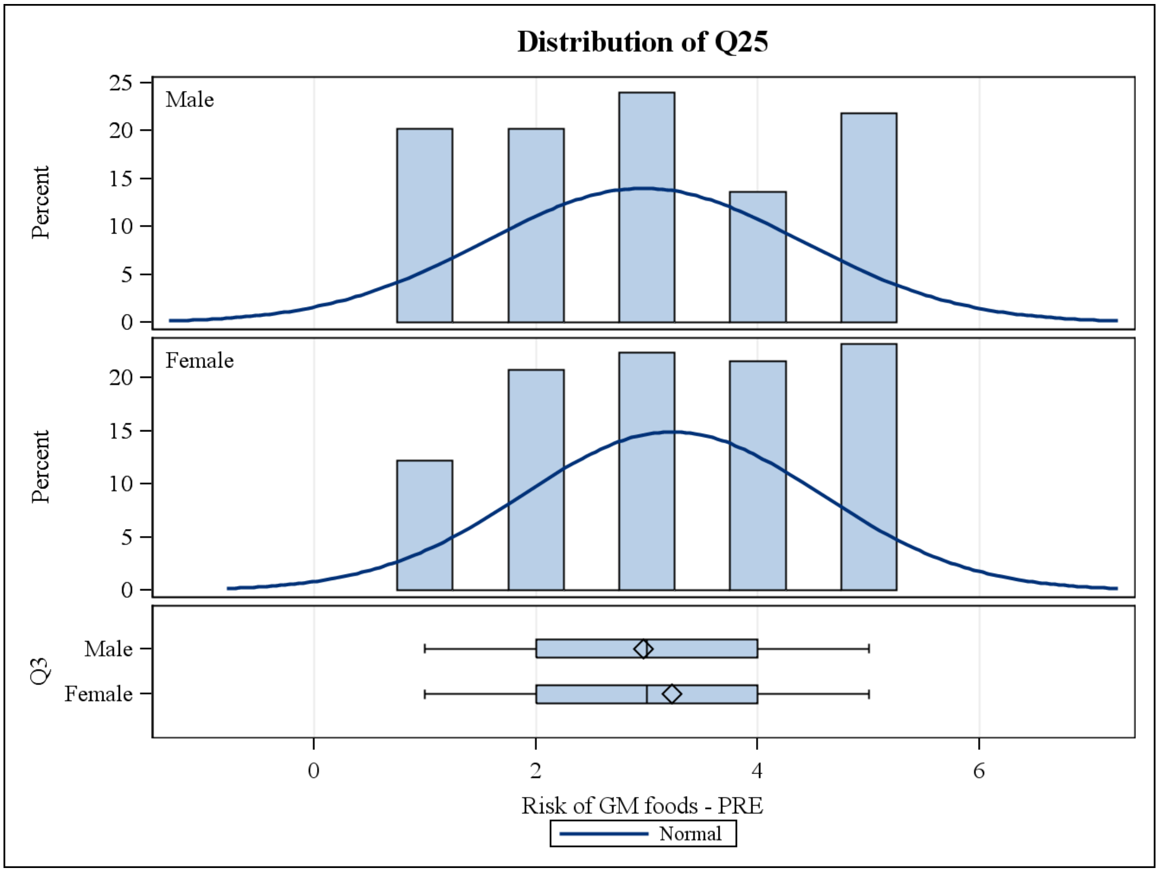

Figure 11. Pre-study distribution for Q. 25 (In your opinion, are GM foods risky for your family?)

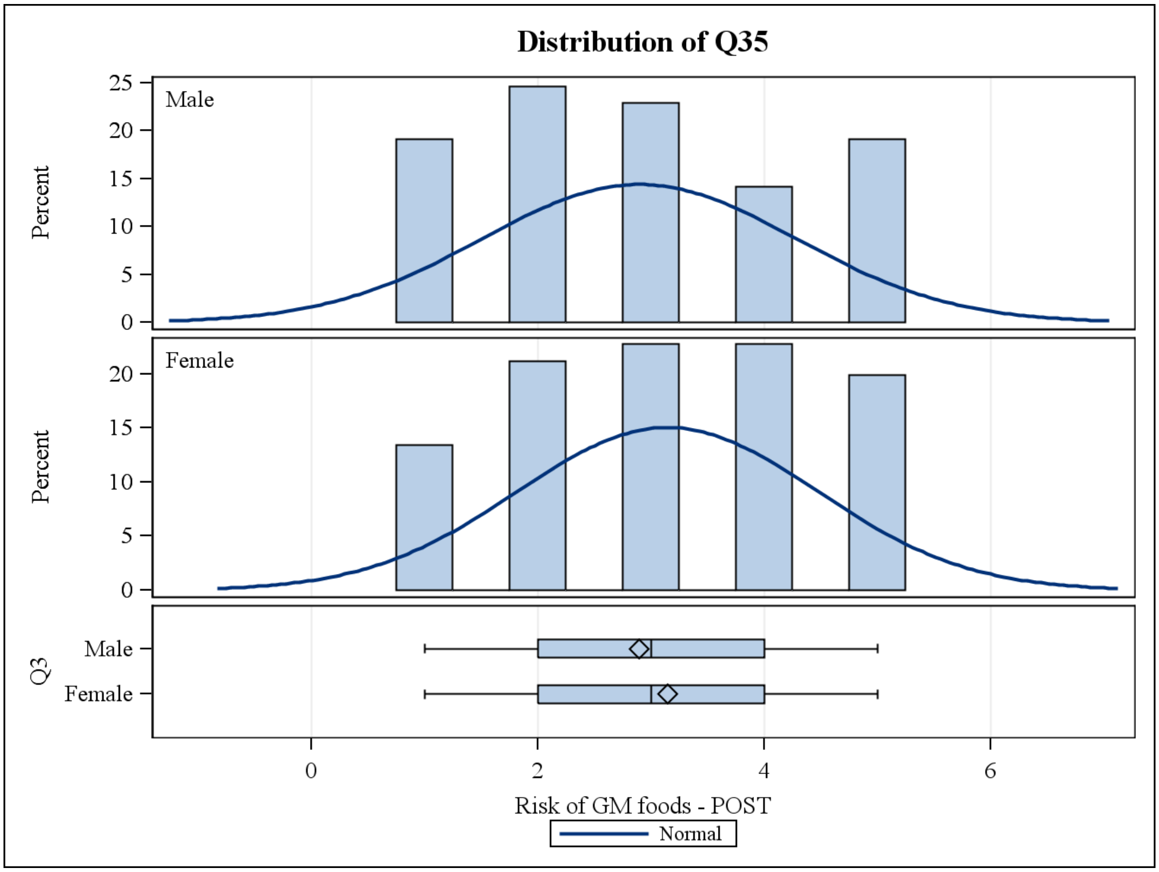

Figure 12. Post-study distribution for Q. 35 (In your opinion, are GM foods risky for your family?)

The distributions show the mean responses for both the male and female participants in the box plots located at the bottom of the figure. The mean-response value for males is 2.9672 in Figure 11 and 2.8962 in Figure 12. The mean-response value for females is 3.2276 in Figure 11 and 3.1463 in Figure 12. We can, thus, see slight differences between the two groups, with males possessing negative perceptions compared to females. The result of a two-sample t-test indicates that there is a moderately significant difference for the mean responses of the male and female participants ($p = 0.0053$ in Figure 11 and $p = 0.0059$ in Figure 12), suggesting that males perceive GM foods to be riskier than the females do (Hypothesis 2 for Research Question 2 from Chapter 3).

5.2. Mind-Map Hypothesis Testing

A detailed region-wise comparison of the bigram strengths of *people*'s perceptions, *collected from the generated mind maps,* based on the responses to a 5-point Likert scale about the health effects of GMOs is depicted in Figures 13 and 14.

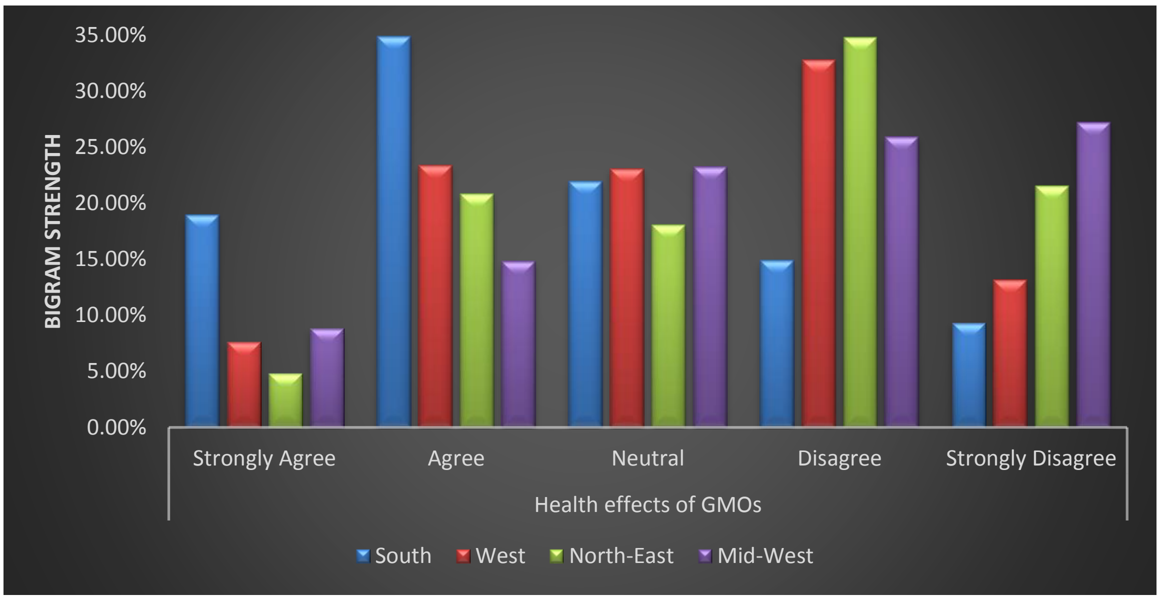

Figure 13. Pre-study bigram-strength responses for the health effects of GMOs for different regions

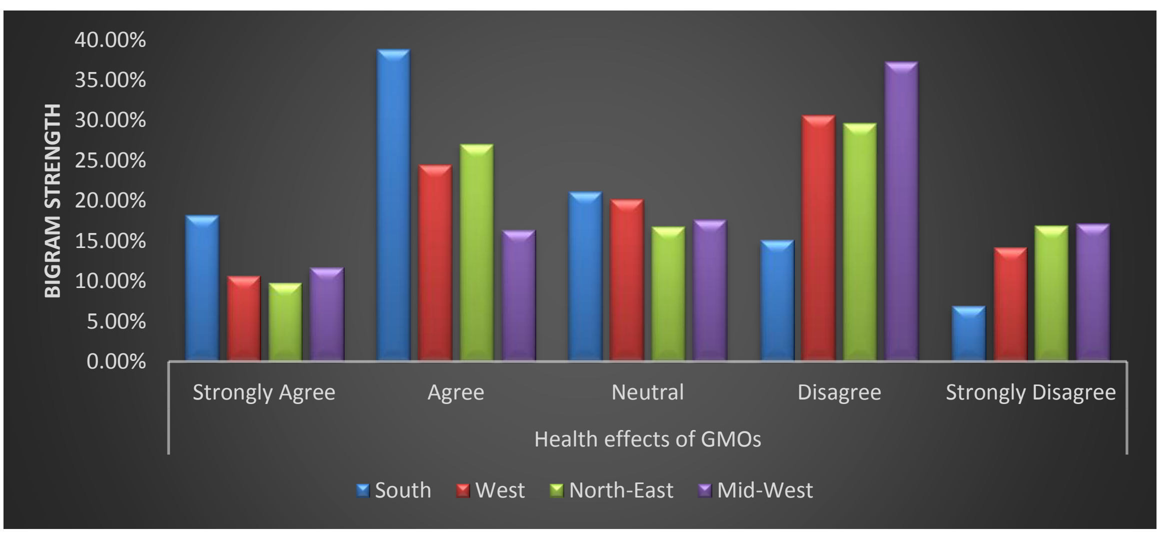

Figure 14. Post-study bigram-strength responses for the health effects of GMOs for different regions

From both figures, we can clearly see that people residing in the *southern* region possessed more positive opinions about GMOs when compared to individuals who lived in other regions.

Figures 15 and 16 plot a detailed comparison of the pre- and post-study responses that were collected from both the male and female participants when they were asked whether they thought GM foods were risky for their families. These were generated using the response ratings for a 5-point Likert scale with an increasing order of *agreement* (*Not at all,* strongly disagree; *Slightly,* disagree; *Moderately,* neutral; *Very,* agree; and *Extremely,* strongly agree) and the respective bigram-strength values from the generated mind maps.

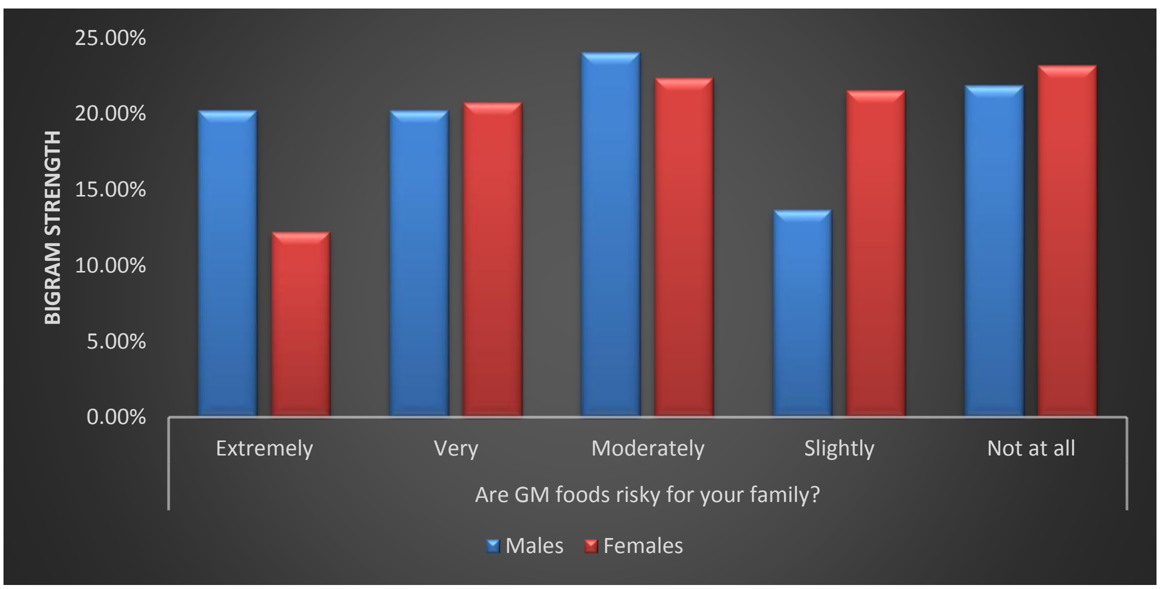

Figure 15. Pre-study bigram strengths for both males and females when asked “Are GM foods risky for your family?”

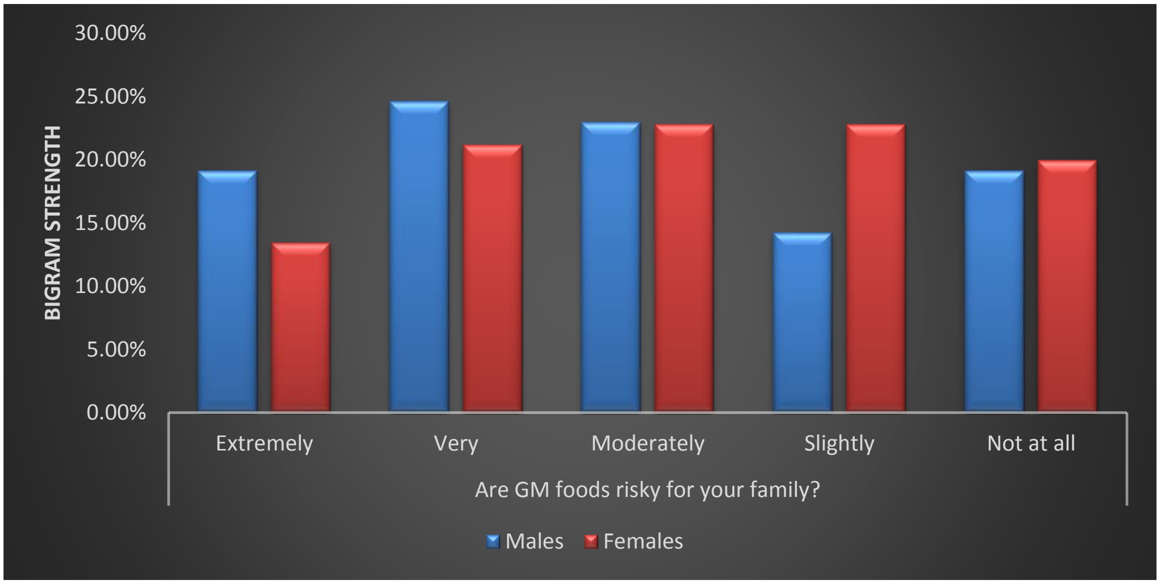

Figure 16. Post-study bigram strengths for both males and females when asked “Are GM foods risky for your family?”

From both figures, we infer that male participants possessed slightly more negative viewpoints regarding GM foods when compared to their female counterparts. Males considered GM foods to be risky for their families.

5.3. Comparison Between Responses from the General Population and Students

We compared and contrasted the responses obtained from participants who were recruited through Amazon Mechanical Turk (general population) and the students from A computer-science course at North Dakota State University. Figures 17 and 18 provide the histogram distributions for both the pre- and post-study responses to compare the groups. Note that the 5-point, Likert-scale values are plotted in coded form on the x-axis (“1” indicates the most negative perception and “5” the most positive).

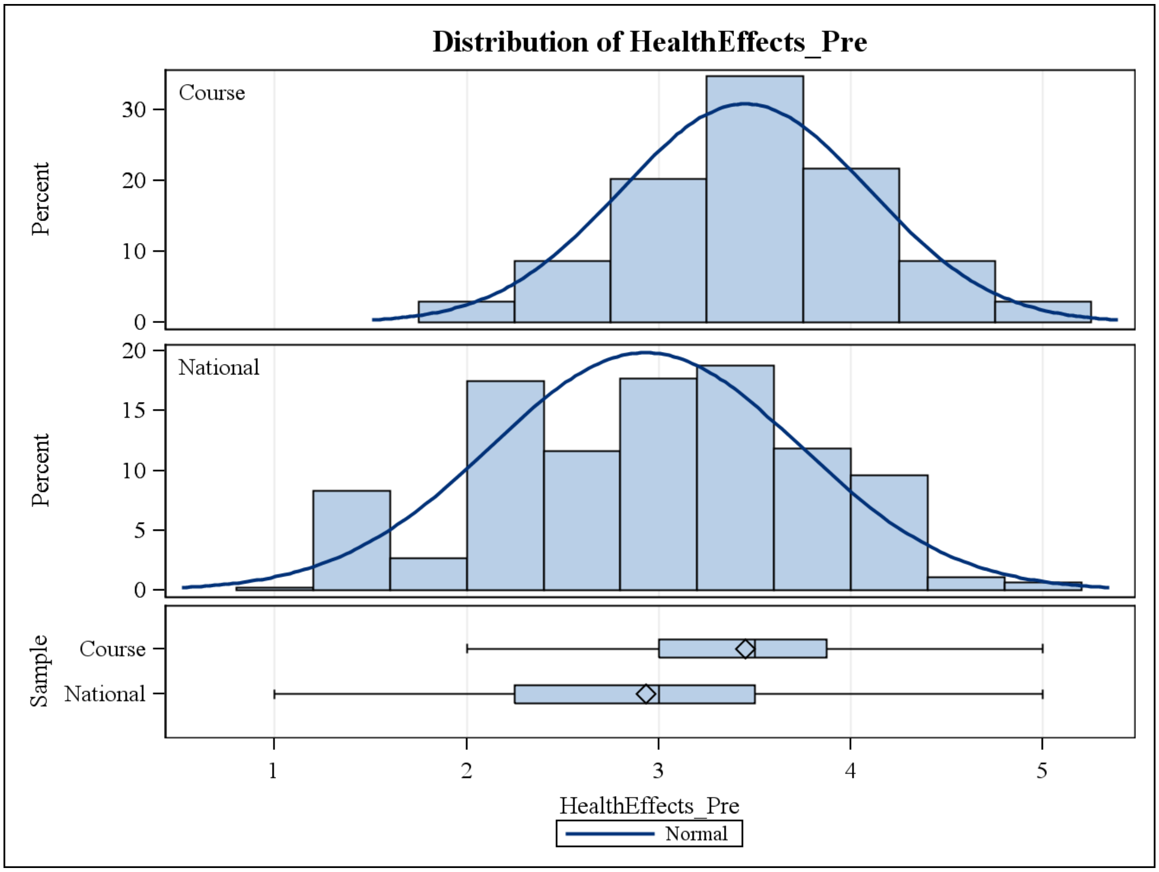

Figure 17. Distribution to compare health effects for the pre-study responses for the general population and students

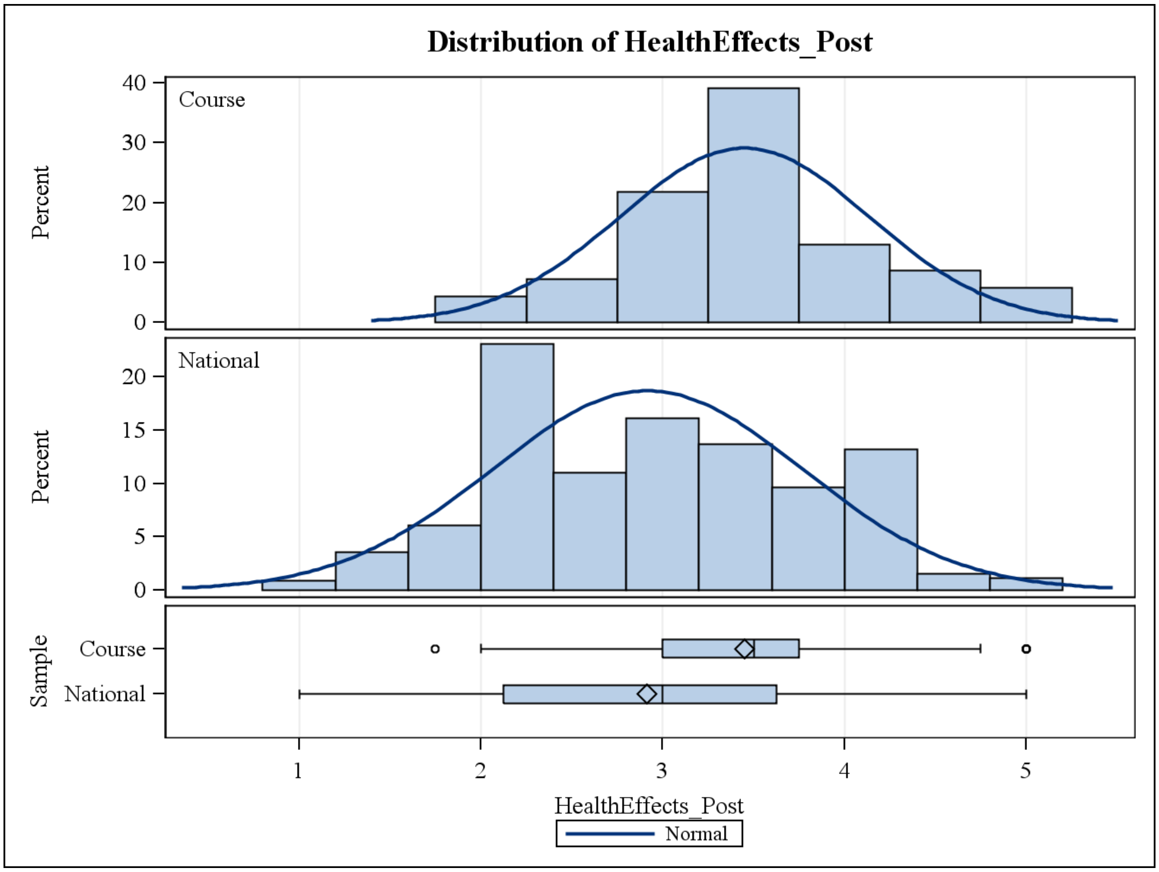

Figure 18. Distribution to compare health effects for the post-study responses for the general population and students

Two-sample t-tests were conducted to analyze the differences in the mean responses for both groups. We found that the p-values for both distributions were less than 0.0001, suggesting a significant difference in the mean responses. The mean-response value for the students was 3.4493 in both figures. The mean-response value for the general-population participants was 2.9309 and 2.9151 in Figures 17 and 18, respectively. From both figures, we can see that students responded more positively about GMOs when compared to participants from the general population.

In terms of bigram strengths for the mind-map network, we compared both groups of participants to measure their pre- and post-study perceptions about the health effects of GMOs. The respective plots are provided in Figures 19 and 20.

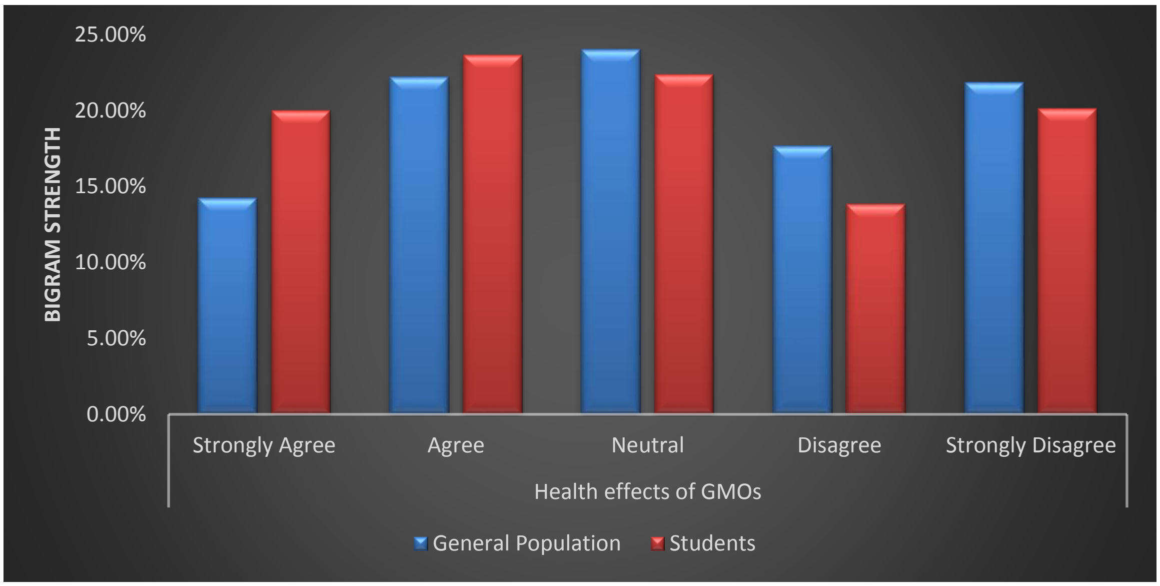

Figure 19. Comparison of bigram strengths of the health effects for the pre-study responses for the general population and students

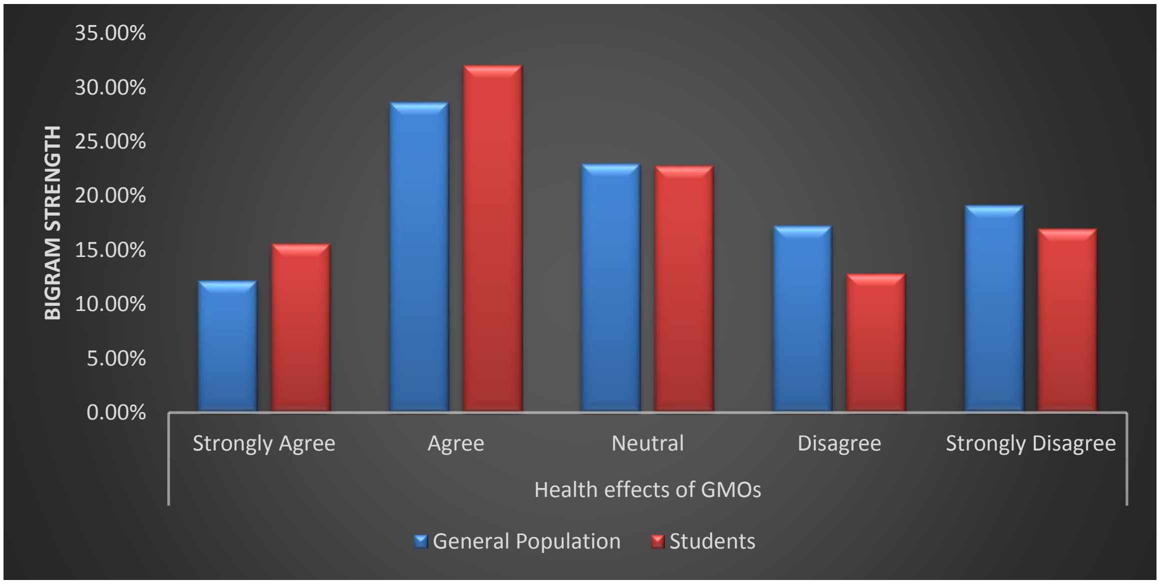

Figure 20. Comparison of bigram strengths of the health effects for the post-study responses for the general population and students

From both figures, we can say that students responded more positively about GMOs when compared to participants from the general population.

5.4. Comparison Between Responses from the General Population and the Control Group

We formed a *control group* of 106 participants who were recruited from Amazon Mechanical Turk with the distinction that these participants did not read any news releases between the pre- and post-study questions. We then compared their responses with the ones obtained from the 446 participants who read the news releases. The tables depicting the perception changes for both the pre- and post-study responses for the individual survey questions for all participant groups are provided in Appendices C, D, and E. Tables 3 and 4 provide the average responses obtained from the general-population participants and the control-group participants on a 5-point Likert scale for all the positive health effects of GMOs (The positively worded questions are aggregated together).

Table 3. Average responses for the positive health effects of GMOs from the Amazon Mechanical Turk general-population participants

	Positive health effects: POST					
Positive health effects: PRE	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	20	17	5	6	3	51
Agree	21	152	34	31	8	246
Neutral	5	31	50	2	4	92
Disagree	0	6	12	7	4	29
Strongly Disagree	0	4	1	17	6	28
Total	46	210	102	63	25	446

Table 4. Average responses for the positive health effects of GMOs from the Amazon Mechanical Turk control-group participants

	Positive health effects: POST					
Positive health effects: PRE	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	9	0	0	0	0	9
Agree	0	36	0	0	0	36
Neutral	1	0	16	1	0	18
Disagree	0	0	1	33	0	34
Strongly Disagree	0	0	0	0	9	9
Total	10	36	17	34	9	106

The values on the diagonal in both tables indicate the average for the actual participants' responses. For example, on average, 152 people from Table 3 have *agreed* to the statement that GMOs possess positive health effects, and likewise, 36 people from Table 4 have *agreed* with the same statement. To understand the changes in perceptions for the responses, we need to read row-wise through the table. In Table 3, for example, 31 people changed their opinion from *Agree* to *Disagree* (row 2), and 6 people changed their opinion from *Disagree* to *Agree* (row 4). Talking about Table 4, we can see absolutely no change in the respective opinions for the control group. This indicates that the news releases had a considerable impact.

It is evident from Table 3 that, out of 51 people who *strongly agreed* initially, 31 (17 + 5 + 6 + 3) people, i.e., 60%, changed their opinions after reading the news releases. Likewise, of the 246 people who *agreed* initially, 94 (21 + 34 + 31 + 8) people, i.e., 38%, changed their opinions. Of the 92 who stated *Neutral* in the first place, 42 (5 + 31 + 2 + 4), i.e., 45%, changed their mind; of the 29 who *disagreed* before, 22 (0 + 6 + 12 +4), i.e., 75%, changed their mind; and of the 28 who *strongly disagreed* before, 22 (0 + 4 + 1 + 17), i.e., 78%, changed their opinions. This phenomenon is depicted in Table 5.

Table 5. Changes in the average responses for the positive health effects of GMOs from the Amazon Mechanical Turk general-population participants

Positive health effects: PRE	Total responses: PRE	Changes in responses: POST	% of changes in responses
Strongly Agree	51	31	60%
Agree	246	94	38%
Neutral	92	42	45%
Disagree	29	22	75%
Strongly Disagree	28	22	78%
Total	446	211	47%

We infer that the smaller the sample size of people in the pre-stage, the higher the percentage of people who change their opinions. In other words, the probability of changing opinions is greater for small sample sizes. It is worth noticing that, out of 297 (51 + 246) people who stated their earlier opinions as *Strongly Agree* or *Agree*, 48 (9 + 39) changed their opinions to *Disagree* or *Strongly Disagree*, i.e., 16.16%; whereas, out of 57 (29 + 28), people who changed their opinions from *Disagree* or *Strongly Disagree* to *Agree* or *Strongly Agree* is 10 (6 + 4), i.e., 17.54%.

Tables 6 and 7 provide the average responses obtained from the general-population participants and the control-group participants (both from Amazon Mechanical Turk), on a 5-point Likert scale, for all the negative health effects of GMOs (negatively worded questions aggregated together).

Table 6. Average responses for the negative health effects of GMOs from the Amazon Mechanical Turk general-population participants

	Negative health effects: POST					
Negative health effects: PRE	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	5	9	23	0	0	37
Agree	4	36	31	3	0	74
Neutral	3	44	147	40	2	236
Disagree	0	8	28	45	11	92
Strongly Disagree	0	0	2	3	2	7
Total	12	97	231	91	15	446

Table 7. Average responses for the negative health effects of GMOs from the Amazon Mechanical Turk control-group participants

	Negative health effects: POST					
Negative health effects: PRE	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	3	1	0	0	0	4
Agree	0	24	1	0	0	25
Neutral	0	1	50	1	0	52
Disagree	1	2	1	18	0	22
Strongly Disagree	0	0	0	0	3	3
Total	4	28	52	19	3	106

From the previous tables, we can see that, on average, 45 people from Table 6 *disagreed* with the statement that GMOs possess negative health effects, and likewise, 18 people from Table 7 *disagreed* with the same statement. Also, in Table 6, 8 people changed their opinion from *Disagree* to *Agree* (row 4), and 3 people changed their opinion from *Agree* to *Disagree* (row 2). Talking about Table 7, we can see that only 2 people changed their opinion from *Disagree* to *Agree* (row 4), and no one changed his/her opinion from *Agree* to *Disagree* (row 2). This indicates how people considered that GMOs possess more positive health effects than negative health effects.

Similarly to Table 5, Table 8 indicates the changes in the average responses for the negative health effects about GMOs that were received from the general-population participants.

Table 8. Changes in the average responses for negative health effects about GMOs from the Amazon Mechanical Turk general-population participants

Negative health effects: PRE	Total responses: PRE	Changes in responses: POST	% of changes in responses
Strongly Agree	37	32	86%
Agree	74	38	51%
Neutral	236	89	37%
Disagree	92	47	51%
Strongly Disagree	7	5	71%
Total	446	211	47%

It seems obvious that, when the questions are negatively worded, most people who earlier expressed strong views tend to change their opinions. This is clear from Table 8; people who had their views in either the *Strongly Agree* or *Strongly Disagree* categories altered their opinion to the tune of 86% or 71%, respectively. People who had expressed *Agree* or *Disagree* opinions had uniformly altered their opinion, 51% each. People who were in the *Neutral* category altered the least, only 37%.

In Table 5, we see that out of 106 (32 + 74) people who gave their opinion as *Strongly Agree* or *Agree*, only 3 (0 + 3) changed to either *Disagree* or *Strongly Disagree*, i.e., 2.83%; whereas, out of 99 (92 + 7), people who changed their opinions from *Disagree* or *Strongly Disagree* to *Agree* or *Strongly Agree* is 8 (8 + 0), i.e., 8.08%. Comparing this situation with what is shown in Table 5, we may conclude that there were more visible changes in people's opinion about GMOs when the statements were negatively framed.

Figures 21 and 22 depict the histogram distributions that illustrate the comparisons between the pre- and post-study responses about the health effects of

GMOs. Note that the 5-point, Likert-scale values are plotted in a coded form on the lower axis (“1” indicates the most negative perception and “5” the most positive).

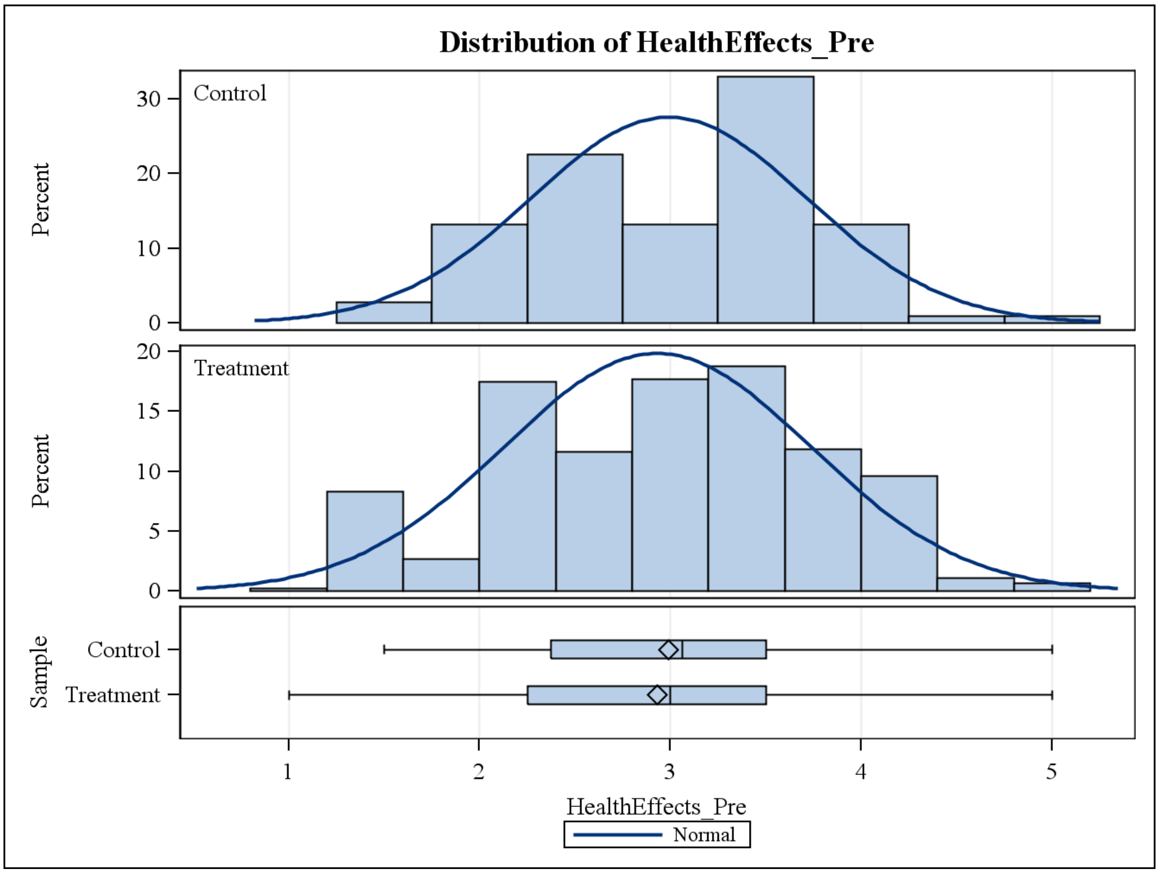

Figure 21. Distribution for the comparison of health effects for the pre-study responses for the general-population and the control-group participants

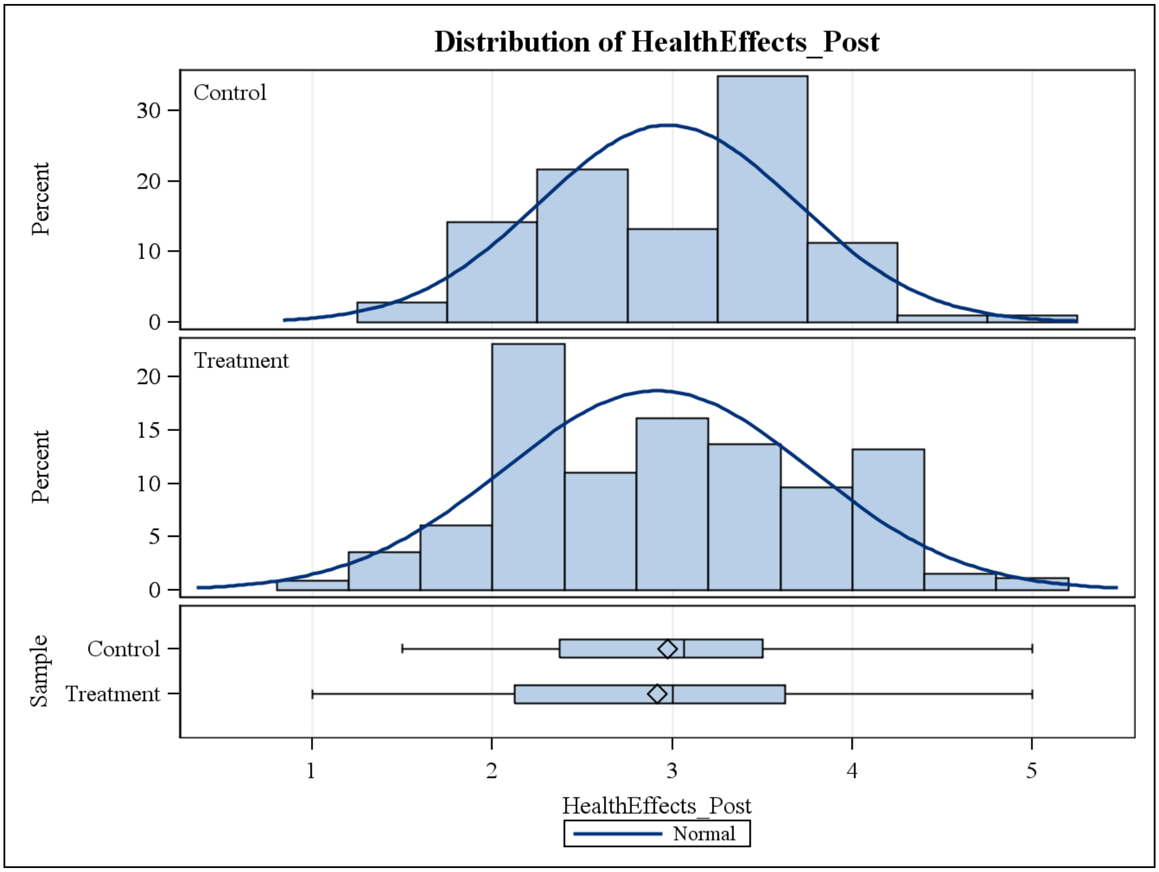

Figure 22. Distribution for the comparison of health effects for the post-study responses for the general-population and the control-group participants

Two-sample t-tests were conducted to analyze the differences with the mean responses for both groups. We found that the p-values for the distributions of the general population and the control group were 0.0183 and 0.0269, respectively, suggesting a difference in the mean responses. The mean-response values for the control group were 2.9917 and 2.9752 in Figures 21 and 22, respectively. The mean-response values for the general-population participants were 2.9309 and 2.9151 in Figures 21 and 22, respectively. From both figures and the mean-response values, we can see that the control-group participants responded slightly more positively (difference less than 1 point on the Likert scale) about GMOs when compared to participants from the general population, but there was a trivial difference in the mean responses for the control group, indicating people's reluctance to change their perceptions about GMOs without news releases.

In terms of bigram strengths for the mind-map network, we compared both groups of participants to measure their pre- and post-study perceptions about the health effects of GMOs. The results are provided in the respective plots of Figures 23 and 24.

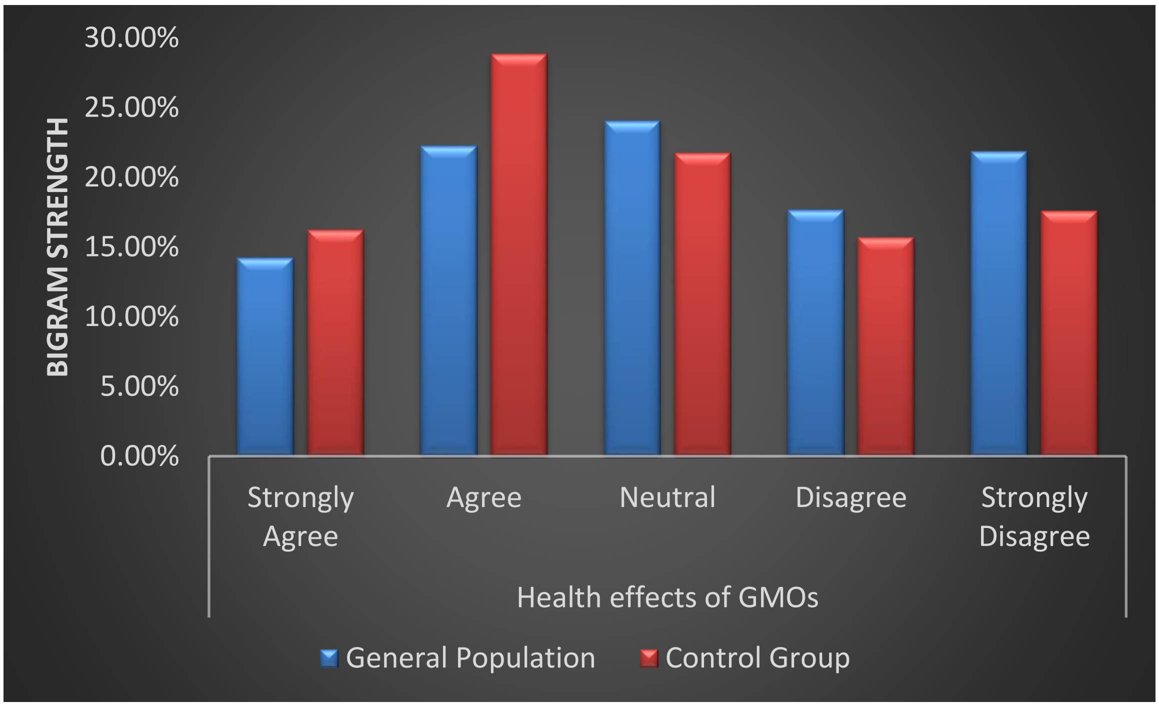

Figure 23. Comparison of the bigram strengths of the health effects for the pre-study responses for the general-population and control-group participants

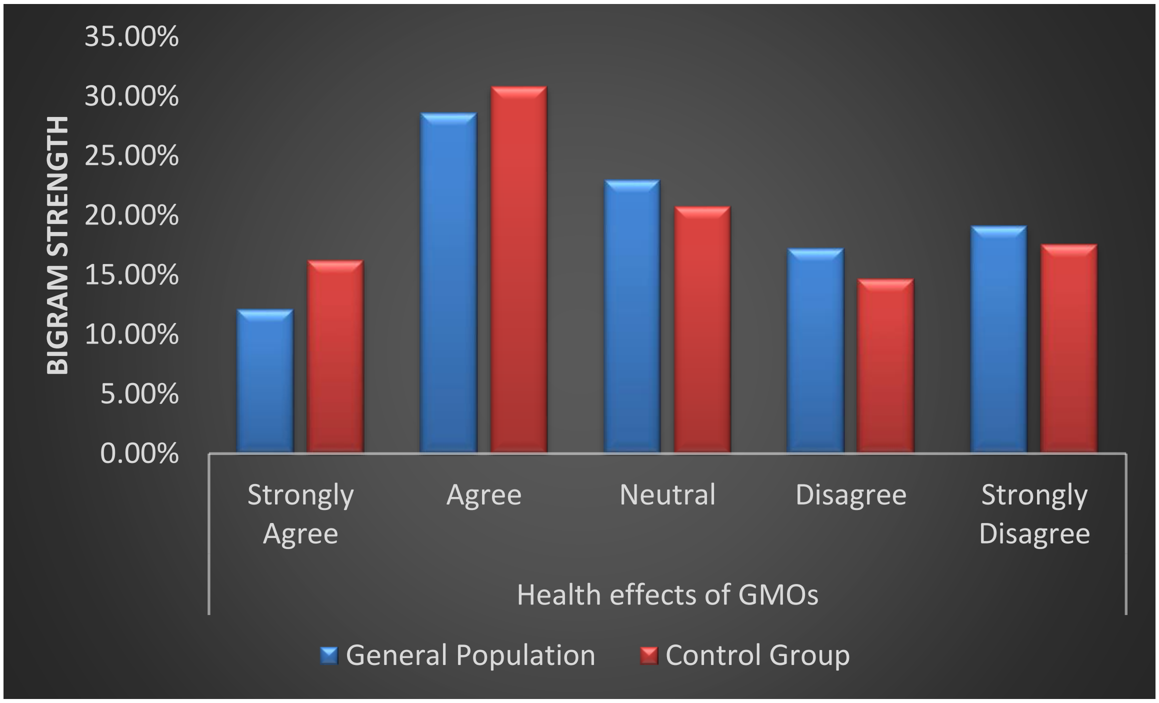

Figure 24. Comparison of the bigram strengths of the health effects for the post-study responses for the general-population and control-group participants

Based on both figures, we can say that the control-group participants responded slightly more positively (difference less than 1 point on the Likert scale) about GMOs when compared to participants from the general population, although we could see a minimal or negligible change in the perceptions of the control-group participants.

5.5. Comparison Between Statistical and Mind-Map Hypothesis Testing

We thought that it would be a good idea to draw some comparisons between the inferences obtained from both the statistical and mind-map hypothesis testing. For the statistical inferences, we considered an alpha value of 0.05, accounting for a 95% confidence interval. To provide a confidence interval for the inferences drawn from the mind-map hypothesis testing as a means to compare the statistical inferences, we applied the concept of Chebyshev’s inequality which can be applied to any distribution that has rather loose bounds (Knuth, 1997). This inequality states that at least $(1 – 1/k^2)$ of the distribution's values are within *k* standard deviations of the mean, indicating the closeness of nearly all values to the mean. We considered $k = 2$ (minimum value of *k*) to account for at least a 75% confidence interval (Kvanli, Pavur, and Keeling, 2005; Chernick, 2011). Table 9 depicts the comparison for those inferences.

Table 9. Comparison for the inferences from the statistical and mind-map hypothesis testing

Hypothesis	Statistical Inference	Mind-Map Inference
People residing in the southern region of the USA respond more positively toward GMOs than people who live in the northeast, western, and mid-west regions of the USA.	We can infer with 95% confidence that people residing in the southern region of the USA responded more positively toward GMOs than people residing in the northeast, west, and mid-west regions. (One-way ANOVA, Duncan's Multiple Range test)	Comparing bigram strengths for both pre- and post-study responses, we can infer, with at least 75% confidence, that people residing in the southern region of the USA responded more positively about GMOs than individuals who resided in the northeast, west, and mid-west regions. (Proportion/Ratio, Chebyshev's inequality)
People from Republican states in the USA believe that GM foods are risky for their families as compared to individuals from Democrat/non-partisan U.S. states.	We can say with 95% confidence that people from states with both Democrat/non-partisan and Republican affiliation had responses that were not significantly different from each other. (Two-sample t-tests)	Comparing bigram strengths for both the pre- and post-study responses, we can say, with at least 75% confidence, that people residing in states with predominant Republican affiliations considered GMOs to be riskier when compared to people living in states that have affiliations with the Democrat/non-partisans parties. (Proportion/Ratio, Chebyshev's inequality)
When asked about GMOs, males tend to speak negatively about them as compared to females.	We can state with 95% confidence that male participants from the entire United States responded more negatively about GM foods when compared to the female participants. (Two-sample t-tests)	Upon comparison of the bigram strengths for both the pre- and post-study responses, we can say, with at least 75% confidence, that males possessed more negative opinions about GMOs when compared to females. (Proportion/Ratio, Chebyshev's inequality)

Additionally, we drew comparisons between the statistical and mind-map inferences obtained from conducting comparisons with different participant groups. For statistical inferences, we, again, considered an alpha value of 0.05 that accounted for a 95% confidence interval. To provide a confidence interval for the inferences drawn from mind-map hypothesis testing, we applied the concept of Chebyshev’s inequality to account for at least a 75% confidence interval (Kvanli, Pavur, and Keeling, 2005; Chernick, 2011). Table 10 depicts the comparison for those inferences.

Table 10. Comparison of the statistical and mind-map inferences for participant groups

Type of Comparison	Statistical Inference	Mind Map Inference
General population vs. Students	We can state with 95% confidence that students responded more positively about GMOs when compared to the general-population participants. (Two-sample t-tests)	Comparing bigram strengths for both the pre- and post-study responses, we can say, with at least 75% confidence, that students possessed more positive opinions about GMOs when compared to general-population participants. (Proportion/Ratio, Chebyshev’s inequality)
General population vs. Control group	We can state with 95% confidence that control-group participants responded slightly more positively about GMOs when compared to the general-population participants. (Two-sample t-tests)	Comparing bigram strengths for both the pre- and post-study responses, we can say, with at least 75% confidence, that control-group participants possessed slightly more positive opinions about GMOs when compared to general-population participants. (Proportion/Ratio, Chebyshev’s inequality)

CHAPTER 6. RISK PERCEPTIONS FOR GENETICALLY MODIFIED ORGANISMS: AN EMPIRICAL INVESTIGATION[1]

6.1. Abstract

Understanding consumers' perceptions about food products is a highly challenging task. The presence of biotechnology, such as genetic modifications, in food products gives rise to differing views about its benefits and risks. We report analyses of survey data that aimed at carefully understanding consumers' risk perceptions about food products that involve genetically modified organisms (GMOs). We report results from an empirical study that investigates the changes in consumer perceptions when exposed to informative material about GMOs in food products. A survey instrument was designed using the Qualtrics API to formulate a set of questions about GMOs (including both the pre- and post-study questionnaire) and all the participants were recruited via the Amazon Mechanical Turk API. The responses were collected and thoroughly analyzed by creating relevant mind maps using the Network Overview Discovery and Exploration for Excel (NodeXL) plugin. The results were further validated by conducting appropriate statistical analyses using the Statistical Analysis System (SAS).

[1] The material in this chapter was co-authored by Pranav Dass, Md. Chowdhury, Damian Lampl and Kendall E. Nygard. Pranav Dass had primary responsibility for designing the entire survey, collecting and categorizing the survey responses, generating the mind maps, and conducting the statistical assessments. Pranav Dass was the primary developer of the conclusions that are advanced here. Pranav Dass also drafted and revised all versions of this chapter. Kendall E. Nygard served as proofreader and checked the statistical analysis conducted by Pranav Dass.

6.2. Keywords

Perceptions, GMOs, Empirical study, Amazon Mechanical Turk, Pre-study, Post-study, Mind maps, NodeXL

6.3. Introduction

Food is an essential ingredient of our daily lives. Scientists have expressed a great deal of interest in activities that involve experimenting with different foods. Primary biotechnology applications for food products include using growth hormones in animals, washing chickens with chlorine, and utilizing genetically modified organisms (GMOs) (Whitman, 2000). Among the biotechnology applications for food products, the most popular and innovative applications are the ones which are associated with GMOs. Genetically modifying organisms can provide properties such as resistance to disease or insects, and higher crop yields. Some popular GMO food products include corn, rice, and dairy products, all of which are consumed widely in our daily lives (Roller and Harlander, 1998). GMO food products are often perceived as posing either benefits or risks (Persley and Siedow, 1999). Consumers often question experiments and changes with food products, forming strong opinions about these technological changes. People may perceive huge risks with these technologies, or they may not care at all. This study aims to understand and analyze the issues surrounding consumers' risk perceptions about such technologies, specifically GMOs.

We conducted an empirical study that investigated the risk perceptions associated with the presence of GMOs in food products. We formulated an approach that used mind maps (Willis and Miertschin, 2006; Beel and Langer, 2011) to explore and analyze these risk perceptions. A mind map can be visualized as a cognitive model of an individual's risk perceptions. The results are validated by applying relevant statistical analyses.

The rest of the paper is organized as follows. Section 6.4 provides a detailed Literature Review about mind maps and the prior studies concerning the risk perceptions for GMOs. Section 6.5 presents the study's objectives along with the desired research questions and hypotheses. In Section 6.6, the study's Experimental Setup is formulated. Section 6.7 provides the performance Results and Analyses. Section 6.8 provides the paper's Conclusion and Future Work.

6.4. Literature Review

The presence of foreign entities, such as GMOs, in food products has sparked the need to conduct research around the world in order to determine consumers' perceptions about the potential risks involved with these entities (Baker and Burnham, 2001; Burton et al., 2001; Baker and Mazzocco, 2002; Burton and Pearse, 2002). There have been previous studies to measure risk perceptions about genetically modified foods but these studies concentrated on few aspects with minimal emphasis on the impact factors, such as trust, ethics, and the environment. One study was conducted by (Bugbee and Loureiro, 2003); they evaluated consumers' purchasing attitudes about these GM foods and designed a theoretical model to address this issue. Another study was conducted by (Han, 2006); he extended the model developed by (Bugbee and Loureiro, 2003) and utilized a survey-based approach to validate his model. Some similar survey-based approaches were done, but all of them considered a limited suite of aspects about the risk perceptions, especially consumers' purchasing behaviors across different countries (Pidgeon et al., 2005; Moon, Balasubramanian, and Rimal, 2006; Onyango, Nayga, Jr., and Govindasamy, 2006). Several studies targeted the labeling of GM foods as a key aspect and formulated theoretical models to address this issue (Onyango, Nayga, Jr., and Govindasamy, 2006).

Our study is unique in the sense that, to date, researchers have addressed this issue by forming theoretical models; no prior work has been done to apply a cognitive or visual approach to the issue. In this study, we introduce a mind-map (associative network) based approach (Willis and Miertschin, 2006) to analyze the risk perceptions about GM foods. Mind maps are constructed using mind-map tools such as MindMeister but only for basic exploratory analyses (Beel and Langer, 2011). We consider several key aspects and impact factors in contrast to the much more limited prior studies. We consider GMO factors in food that pertain to human health, the environment, the economy, ethics, and trust.

6.5. Research Objectives

Over time and with advancements in GMO technology, the consumers' risk perceptions change. Some consumers perceive benefits associated with the changes, welcoming the changes; on the other hand, some consumers perceive high risk and, thereby, tend to reject and question such changes. The reality is that it is difficult to convince others about *change* and to alter their pre-conceived attitudes, especially regarding food products.

This study aims to analyze changes in consumer perceptions about GMO food products. We investigate whether consumers tend to modify their prior opinions about

GMOs when they are deliberately exposed to informational material that highlights the risks and benefits of GM foods.

6.5.1. Design instruments

We designed a detailed questionnaire using the Qualtrics Survey API (“Qualtrics API”, 2016) and administered the survey online. This questionnaire consisted of demographic questions, such as age, ethnicity, education level, and salary, as well as a set of pre-study and post-study questions that were related to GMOs and the effects of the presence of GMOs in food products. In addition, the questionnaire had two recent news releases that highlighted both the positive and negative aspects of GMOs (“Commission authorizes”, 2015; “GMO inside”, 2015). These news releases separated the pre-study and post-study questions. The first news release described the adoption of a variety of GM crops, such as maize and soybeans which were declared *safe* by the European Union (EU), with authorizations valid for 10 years. The second news release explained the announcement of two Hershey’s chocolate products (milk chocolate and kisses) to be non-GMO by the end of that year. This decision was made to support a GMO campaign that had been running for two years.

6.5.2. Research questions and hypotheses

The following research questions and hypotheses were formulated for this study.

Research Question 1: Does regional location play a role in forming people’s perceptions about GMOs?

Hypothesis 1: People residing in the *southern* region of the USA respond more positively about GMOs than individuals who live in other U.S. regions.

Research Question 2: Does a state's predominant political-party affiliation influence residents' perceptions about GMOs?

Hypothesis 2: People from *Republican* states in the USA believe that GM foods are risky for their families as compared to individuals who live in *Democrat/non-partisan* U.S. states.

6.6. Experimental Setup

About 447 participants were recruited uniformly within the United States via the Amazon Mechanical Turk API (Amazon Mechanical Turk API, 2016). Each participant was asked to complete the pre-study survey, followed by being asked to read the two news releases. Each respondent then completed the post-study questionnaire (consisting of the same questions) in order to produce a complete response. Each pre-study and post-study question consisted of multiple statements that highlighted the effects of GMOs pertaining to a wide range of impact factors related to health, the environment, the economy, ethics, and trust with both GM and government institutions that were responsible for conducting and approving the research involving GMOs. Every participant rated each statement on a 5-point Likert scale (5, Strongly Agree; 4, Agree; 3, Neutral; 2, Disagree; and 1, Strongly Disagree). These results were captured anonymously to produce the data set for the analyses. The 447 participants consented to participate and completed the study. The following experiments were conducted to evaluate the given research questions and hypotheses.

6.6.1. Experiment 1: U.S. states by region

The collected responses were categorized into regions as shown in Figure 25 ("United States region maps", 2016).

West: 184 people (41.16%) participated in the study;

Midwest: 54 people (12.08%) participated in the study;

South: 155 people (34.68%) participated in the study; and

Northeast: 54 people (12.08%) participated in the study.

Figure 25. United States region map

6.6.2. Experiment 2: U.S. states by political-party affiliation

The collected responses for the U.S. states were categorized in accordance with the predominant political-party affiliations as shown in Figure 26 ("United States political", 2016).

Democrat & non-partisan (in blue and black colors): 135 people (30.20%) participated in the study; and

Republican (in red color): 312 people (69.80%) participated in the study.

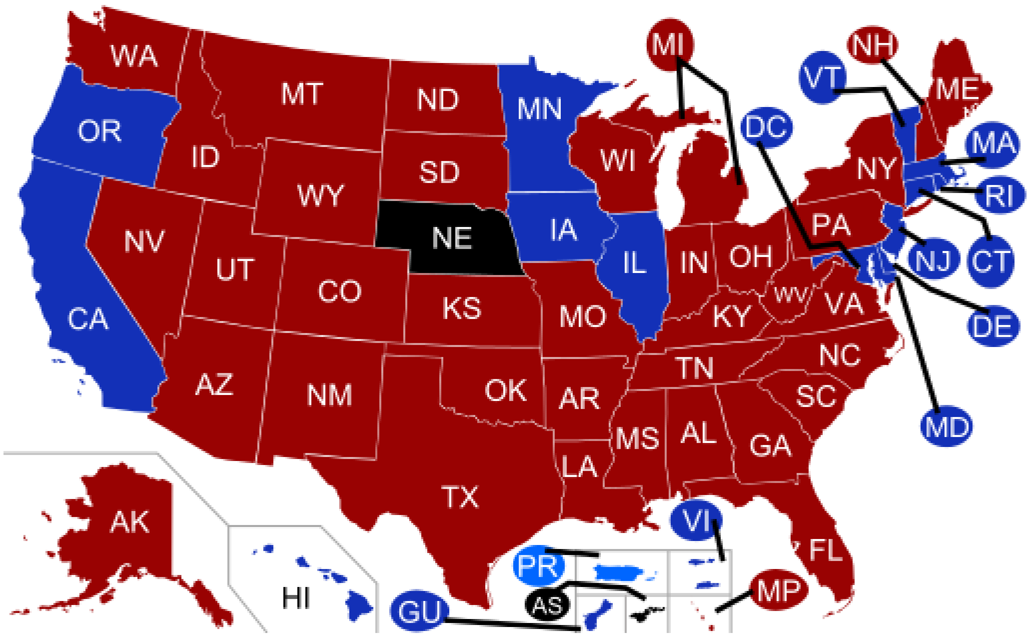

Figure 26. United States political-party map

6.7. Results and Analyses

This section provides a detailed analysis of the quantitative data, including the participants' recorded responses. This section is organized around the two hypotheses presented in Section 6.5.2. All the mind maps were created using NodeXL version 2014 (Hansen, Shneiderman, and Smith, 2010) and all the edge weight values were normalized within the interval (0, 1). An alpha value of 0.05 was used for all statistical analyses conducted with SAS version 9.3.

6.7.1. Analysis of the responses for Hypothesis 1

This section provides analyses about the connection between a participant's regional location and his/her corresponding responses. Two analysis methods are employed in this section.

6.7.1.1. Analysis using mind maps

From here on, we refer to each word as a *node* and each link connecting two nodes as an *edge*. In this study, we generated *undirected* mind maps for analysis. The following procedure was utilized to generate a single mind map (Willis and Miertschin, 2006) for the responses.

a. ***Formulate a glossary of words:*** A dense glossary of words was constructed; it consisted of both positive ("Glossary of positive", 2016) and negative ("Glossary of negative", 2016) words related to GMOs. The terms *positive* and *negative* serve as the two categories directly linked to the term *GMO* (root node) in the mind map. All the positive words are directly linked to the term *positive,* and similarly, all the negative words are directly linked to the term *negative*.

b. ***Assign a statement to the relevant word(s):*** Each statement related to questions about the effects of GMOs were carefully assigned as a sub-category to a relevant word from the glossary, providing a direct link between a word and the statement.

c. ***Calculate and assign the appropriate weight to each word pair:*** Each edge consisted of two nodes, and the combination of these two nodes formed a *word pair*. For example, *(GMO, Positive)* acted as a word pair in the mind map. An edge's weight value signified a word pair's *popularity (or strength)*. To assign weight to word pair *x*, its occurrence is thoroughly searched in a set of documents that contain reviews about GMO features (an article, news release, journal, etc.) and a count is computed for that word pair. This technique is inspired by similar work (Turney, 2002). Then, the word pair is assigned a rank, $y \in \{1, ..., k\}$ (k = 2 in this case), with k being the number of word categories. This ranking model is based on the *Perceptron Ranking (Pranking) Algorithm*. This model stores a weight vector, $w \in R^n$ and divides the real line into k segments, one for each possible rank. The model first scores each input with the weight vector: $score(x) = w \cdot x$, locates *score* (x) on the real line, and returns the appropriate rank as indicated by the boundaries. With the new correct rank, the corrected score is re-calculated. Finally, the score is normalized within the open interval (0, 1) (Crammer and Singer, 2001; Snyder and Barzilay, 2007). Proceeding in this manner, we assigned weights to each word pair.

d. ***Link the survey response to each question:*** The count for each survey response (previously described in Section 4) was calculated and normalized within the open interval (0, 1) in accordance with the previously calculated weight values. Then, each response was linked to the corresponding question with the appropriate weights. This resulted in generating exactly 5 response values for each question. Note that there are 2 mind maps for a single response: the pre-study mind map and the post-study mind map.

Figure 27 depicts a complete pre-study mind map that was constructed using NodeXL for the responses collected from states in the *southern* region. The Vertices and Edges worksheets in the workbook were used by the NodeXL Graphical User Interface (GUI) to prepare this graph.

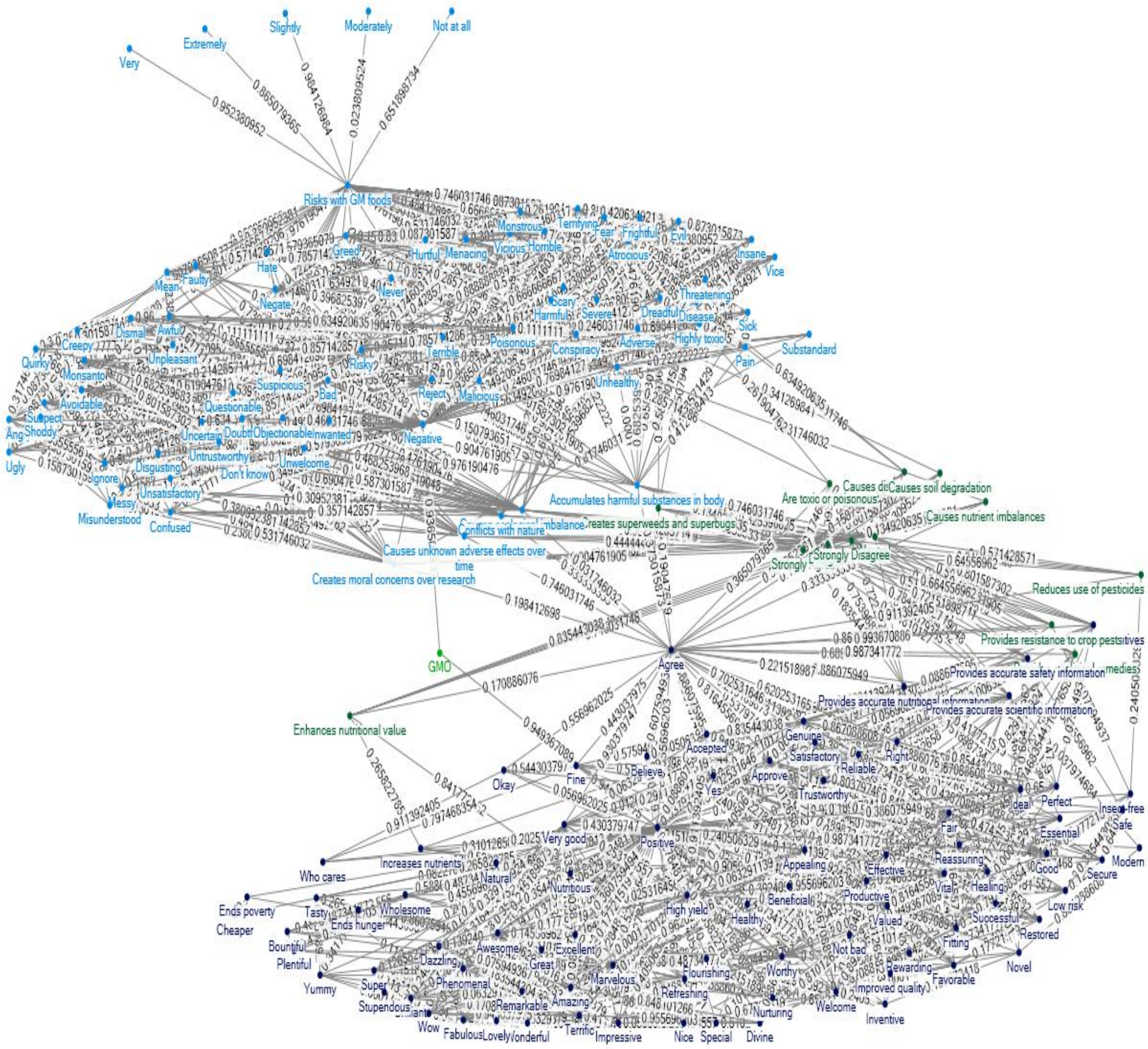

Figure 27. Pre-study mind map for the *Southern* region

A detailed region-wise comparison for the percentages of people, collected from the generated mind map, who provided their response ratings on a 5-point Likert scale (SA = Strongly Agree, A = Agree, N = Neutral, D = Disagree, and SD = Strongly Disagree) when asked about whether GMOs provided medicinal remedies as one of the health effects is depicted in Figures 28 and 29. From the figures, it can be seen that people from the *southern* region mostly agree with the statement and that their agreement percentages are higher than the ones for individuals who live in other regions.

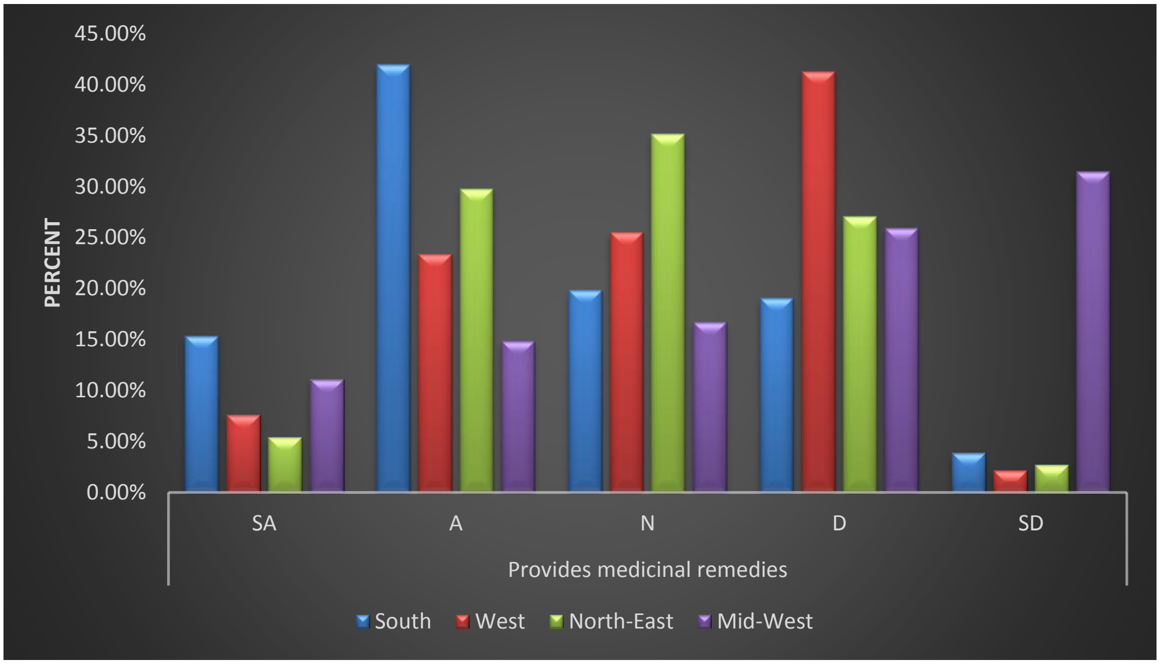

Figure 28. Pre-study percentage response ratings for the question “Do GMOs provide medicinal remedies?”

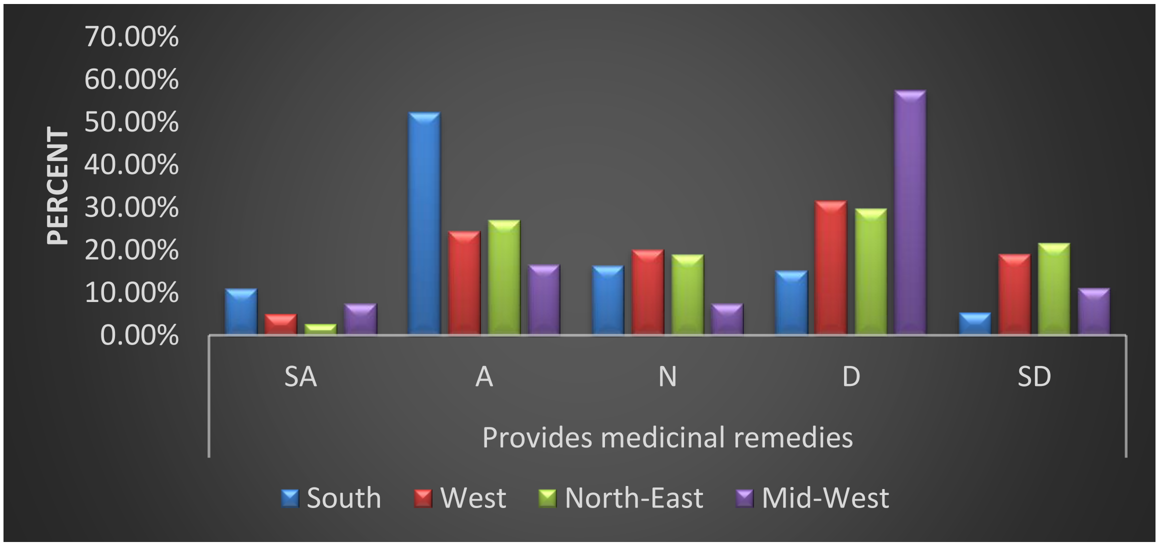

Figure 29. Post-study percentage response ratings for the question “Do GMOs provide medicinal remedies?”

6.7.1.2. Statistical analysis

To validate the analysis results obtained through the mind-map technique, we conducted a thorough statistical analysis. Figures 30 and 31 plot the mean-response results for the one-way ANOVA test for the pre-study and post-study responses for the same question that was described in the previous section. Note that the 5-point, Likert-scale values are plotted in coded form on the left axis (Values from 1 through 5 are in increasing order of *agreement*).

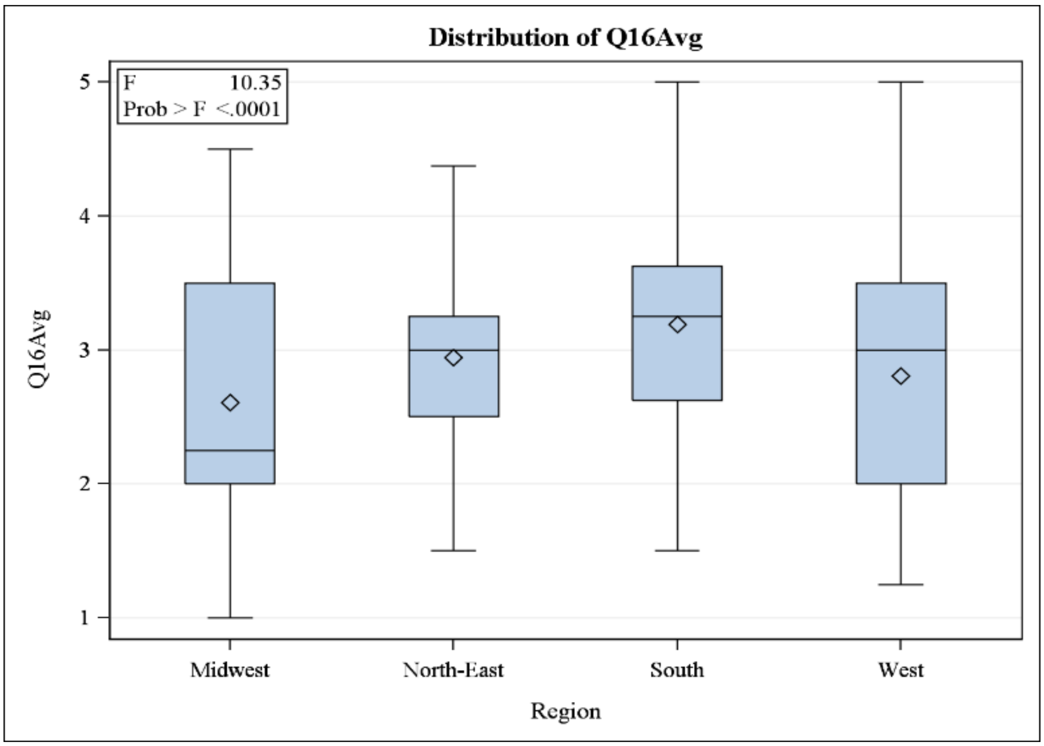

Figure 30. Pre-study box-plot distribution for the question “In your opinion, what could be the health effects of GMOs?”

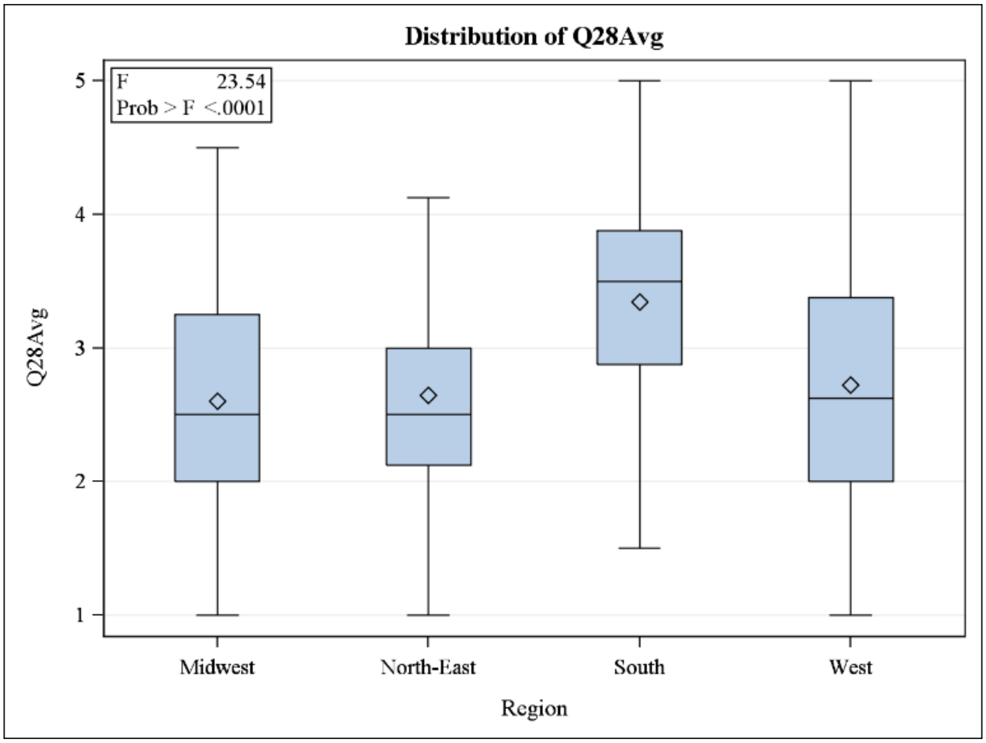

Figure 31. Post-study box-plot distribution for the question “In your opinion, what could be the health effects of GMOs?”

From the box-plot distributions, we can clearly deduce that, in both distributions, the mean values for the *southern* region are the highest when compared to the ones in other regions. The mean value in Figure 30 is 3.1895, whereas, in Figure 31, it has increased to 3.3452. The significant increase in the mean values might be because more people have changed their responses to either *Agree* or *Strongly Agree*.

The p-values for both distributions are less than 0.0001, which indicates that we cannot reject the *null hypothesis*, meaning that there is a significant difference in the regional means. Duncan’s Multiple Range test was utilized to measure which regional means were significantly different. Basically, this reduces the probability of a *false positive*, i.e., rejecting the null hypothesis when it is true. Figures 32 and 33 provide the Duncan groupings, along with their respective mean differences, for both the pre-study and post-study responses from the different regions.

Duncan Grouping	Mean	Region
A	3.1895	South
B	2.9421	Northeast
B, C	2.8043	West
C	2.6088	Midwest

Figure 32. Pre-study Duncan groupings for the question “In your opinion, what could be the health effects of GMOs?”

Duncan Grouping	Mean	Region
A	3.3452	South
B	2.6435	Northeast
B	2.7227	West
B	2.6042	Midwest

Figure 33. Post-study Duncan grouping for the question “In your opinion, what could be the health effects of GMOs?”

It is evident from Figures 32 and 33 that means with the same letter are not significantly different. From Figure 32, the *southern* region has an “A” grouping; the *north-east* and *western* regions have the “B” grouping; and the *west* and *mid-west* regions have the “C” grouping. This indicates that mean responses from the *southern* region are significantly different from all the other regions, whereas, the mean responses from the *north-east* and *western* regions are not significantly different. Also, the mean responses from the *west* and *mid-west* regions are not significantly different, but the mean responses from the *north-east* and *mid-west* regions are significantly different.

Likewise, we can infer from Figure 33 that the mean responses from the *southern* region are significantly different from all the other regions, whereas, the mean responses from the *north-east*, *mid-west,* and *western* regions are not significantly different. This validates our original hypothesis that people residing in the *southern* region respond more positively about GMOs when compared to people who live in other regions and provides a strong analytical result for *Research Question 1*.

6.7.2. Analysis of the responses for Hypothesis 2

This section analyzes the connection between a participant's state affiliation with its predominant political party and his/her corresponding responses. Two analysis methods are employed for this section.

6.7.2.1. Analyses using mind maps

The same procedure was utilized to generate the relevant mind maps for the responses as was described in Section 6.6.1.

A detailed comparison about the percentage of people residing in states which possess affiliations with predominant political parties, collected from the generated mind map, who provided their response ratings on a 5-point Likert scale (SA = Strongly Agree, A = Agree, N = Neutral, D = Disagree, and SD = Strongly Disagree) when asked about whether GMOs are responsible for creating super-weeds and super-bugs as one of the environmental effects is depicted in Figures 34 and 35. The figures clearly show that people residing in Republican states mostly support the argument and those percentages are quite a bit higher than the ones from other parties.

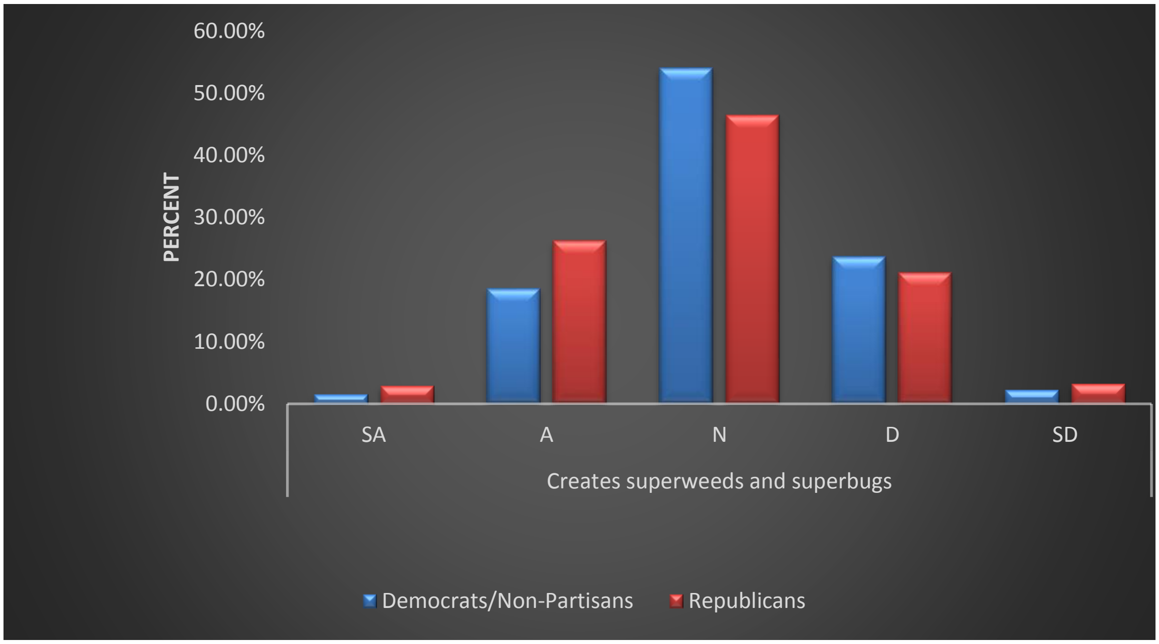

Figure 34. Pre-study percentages depicting the response ratings for the question “Do GMOs create super-weeds and super-bugs?”

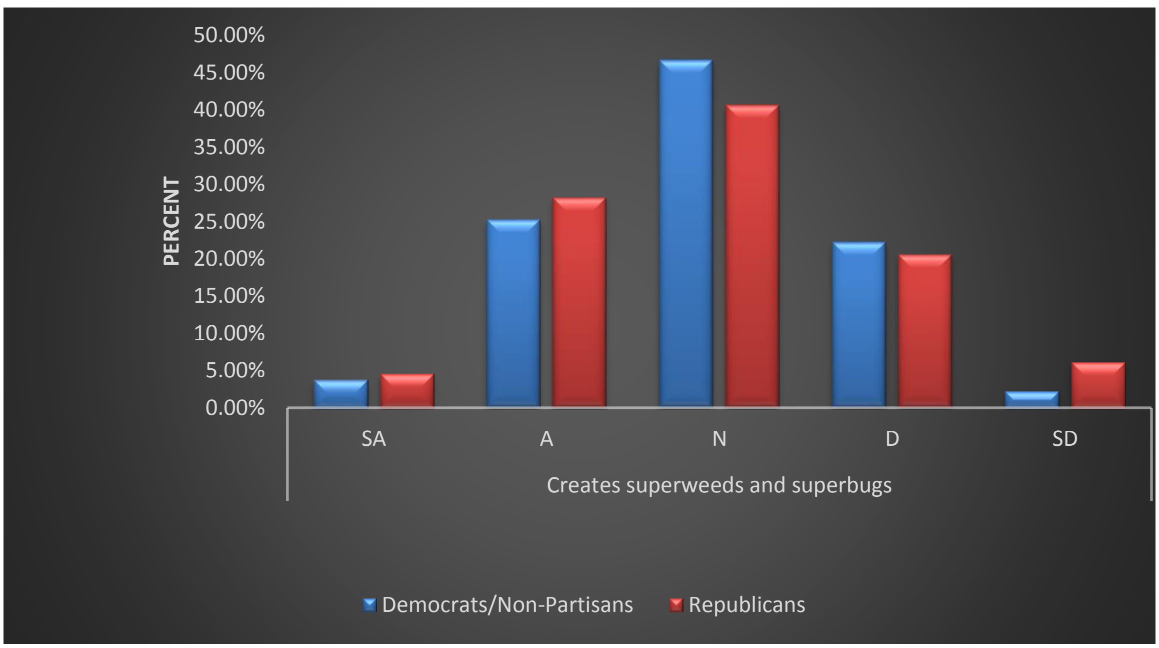

Figure 35. Post-study percentages depicting the response ratings for the question “Do GMOs create super-weeds and super-bugs?”

6.7.2.2. Statistical analysis

To validate the analysis results obtained through the mind-map technique, we conducted a thorough statistical analysis. Figures 36 and 37 plot the mean-response results for the two-sample t-tests obtained from the pre-study and post-study responses for the same question that was described in the previous section. Note that the 5-point, Likert-scale values are plotted in coded form on the bottom axis (The values from 1 through 5 are in increasing order of *agreement*).

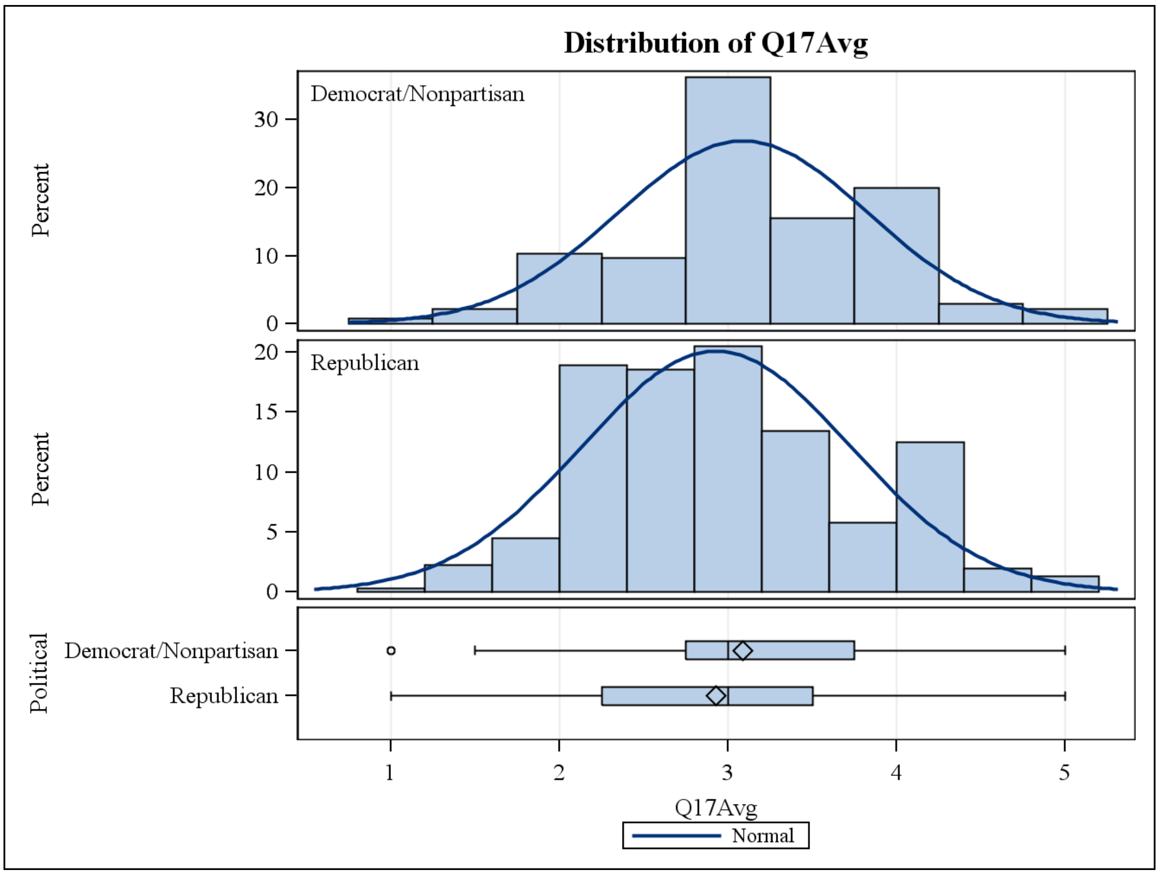

Figure 36. Pre-study distribution for the question “In your opinion, what could be the environmental effects of GMOs?”

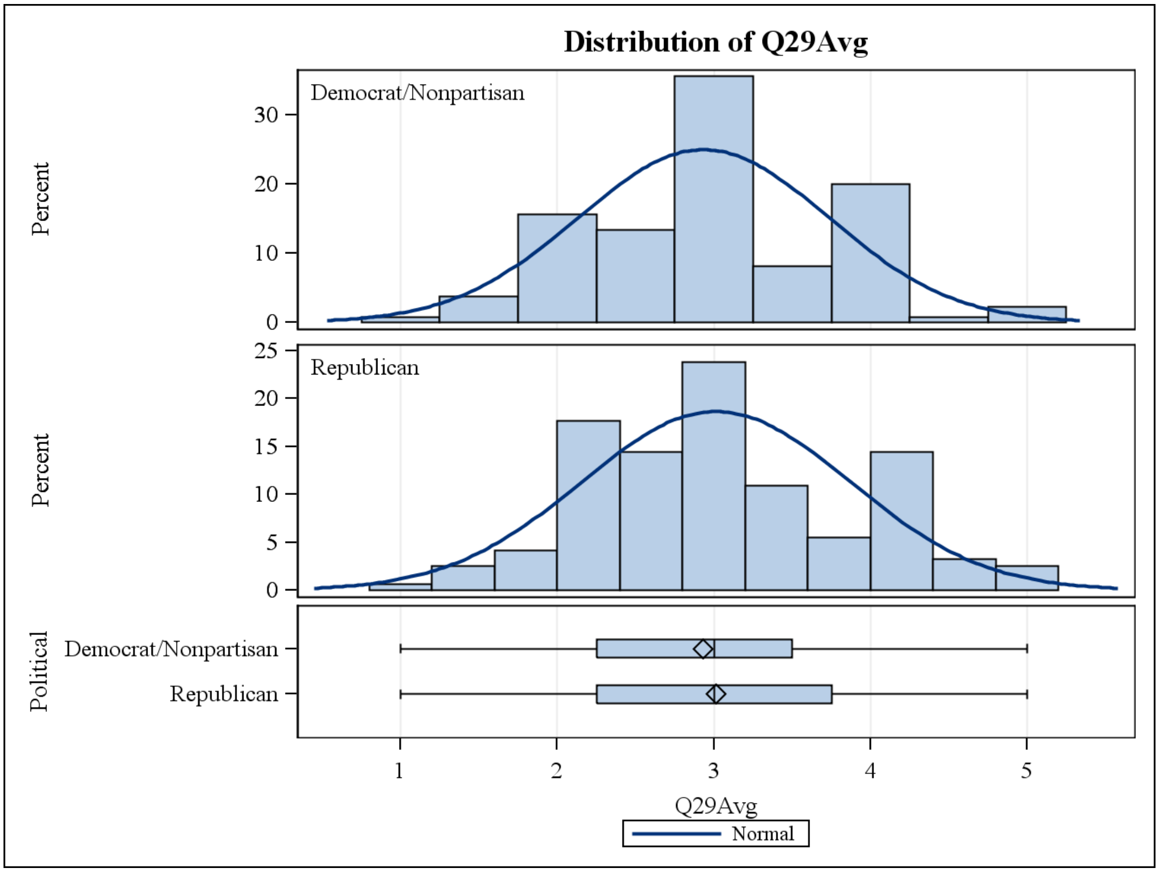

Figure 37. Post-study distribution for the question "In your opinion, what could be the environmental effects of GMOs?"

The t-test distributions depict the mean responses for both political parties on the horizontal bars located at the bottom of the distributions. We can see significant differences in the mean responses (p = 0.0454) of Figure 36 for both the groups and can easily conclude that the *Republicans* do not quite agree with the statements that GMOs have positive environmental effects. However, the mean responses (p = 0.0346) from Figure 37 are very close to each other, and the distributions are very close to being normal. Because the mean-response values for *Republicans* are almost identical to the distribution's midpoint, we cannot say with full confidence that all *Republicans* dislike GMOs or consider GMOs risky for their families.

From the mind-map analysis, *Hypothesis 2* is validated. However, from the statistical analysis, we could not fully validate the hypothesis, but it is suggested that more *Republicans* consider GMOs of little risk to their families.

6.8. Conclusions and Future Work

In this study, we designed an approach to understand consumers' risk perceptions about GMOs using mind maps. We designed an online survey that dealt with collecting both pre-study and post-study participant responses regarding various effects of the GMOs' presence in food products, such as health, the environment, the economy, etc. We formulated two key research questions that were based on the collected responses about people's regional locations and their states' predominant political-party affiliation. Then, we tested the related hypotheses by conducting a relevant analysis to generate the mind maps and validated the results with the appropriate statistical analysis. Our findings established that people from the *southern* region respond more positively about GMOs when compared to people who lived in other regions. Also, we established that people from both *Democrat/non-partisan* and *Republican* affiliated states have similar perceptions about GMOs. In addition to categorizing the collected survey data by different states of residence, there are other possible demographic categorizations, such as gender, age groups, or marital status. In the future, we plan to contrast the results collected from our survey-based approach with results collected from big data feeds from the Twitter social-media platform and to analyze both techniques using artificial-intelligence methods, such as sentiment analysis and data mining. We expect that applying these techniques will further strengthen our study.

6.9. Acknowledgement

We acknowledge Mr. Curt Doetkott of the North Dakota State University Statistical Consulting Service for his assistance with the statistical analyses that were utilized for the project.

CHAPTER 7. GENDER DIFFERENCES IN PERCEPTIONS OF GENETICALLY MODIFIED FOODS[2]

7.1. Abstract

Anecdotal evidence suggests that gender differences play a role in individuals' perceptions about the risks associated with food products. In this study, we obtained data that drive the analyses of gender differences in perceptions about biotechnology, specifically genetically modified organisms (GMOs). Using survey-based methods, we evaluated the opinion differences both before and after educational pieces about GMOs were given to the subjects. Mind maps were developed in a network format in order to illustrate and to provide a framework for some analyses. The networks were configured using the Network Overview Discovery and Exploration for Excel (NodeXL) plugin. The statistical work was conducted using the Statistical Analysis System (SAS). As an alternative data source, Twitter messages were captured using the Twitter-streaming API. The likely gender for the author of each Twitter posting was ascertained through analyses of the author names and the message text. Basic analytics of the Twitter feeds

[2] The material in this chapter was co-authored by Pranav Dass, Yang Lu, Md. Chowdhury, Damian Lampl, Janani Kamalanathan and Kendall E. Nygard. Pranav Dass had primary responsibility for designing the entire survey, collecting and categorizing the survey responses, generating the mind maps, and conducting the statistical assessments. Pranav Dass was the primary developer of the conclusions that are advanced here. Pranav Dass also drafted and revised all versions of this chapter. Kendall E. Nygard served as proofreader and checked the statistical analysis conducted by Pranav Dass.

were conducted for the hypotheses of interest. The study revealed gender differences in risk perceptions, and less-than-complete agreement between the survey and the social-media based studies.

7.2. Keywords

Risk perceptions, GMOs, Gender, Mind maps, NodeXL, Twitter feeds

7.3. Introduction

Using science and technology has greatly increased the world's food supply and has dramatically changed the food's characteristics. Crossbreeding plant and animal varieties has been employed for many years, producing plant cultivar and animal breeds. Crossing among species creates hybrid offspring with broader mixes of inherited traits and characteristics. In today's world, inheritable changes can be introduced to the organisms' DNA through genetic engineering, allowing for new traits and greater control over the traits. GMOs pertaining to food products are referred as GM foods (Whitman, 2000). Biotechnology in the food industry includes engineering food crops, using growth hormones in poultry, and washing chickens with chlorine. This study focuses on genetically engineered food crops. Crops with high value and demand are the most common subjects of genetic engineering. Primary examples include soybeans, corn, and canola. Increased productivity, improved nutrition value, and high resistance to pathogens and herbicides are the suggested benefits of engineering the food crops. However, there are perceptions that biotechnological methods also have risks associated with them, such as producing an accumulation of chemicals and harmful substances in the body. Other common concerns surrounding GM foods are related to regulation, labeling, environmental impact, and monopoly rights that are exercised by corporations. People often take a consistently strong stand in accepting, promoting, or opposing the use of biotechnology in food products.

This study aims to understand and analyze people's perceptions about various GM foods. We formulated an approach using a survey and configured mind maps to analyze these risk perceptions (Willis and Miertschin, 2006; Beel and Langer, 2011). Figure 38 depicts a simple example of a mind map with a single central node that is labeled GMO and multiple terms that are interlinked in the subject's mind (Dass, O'Connor and Schumate, 2015). A mind map can be visualized as an associative network that signifies the strength of the connections among the GMO as a term, related terms, and people's perceptions about GMOs. Thus, a mind map is a model of how an individual (or a population) relates terms to one another and captures how their mind functions concerning a topic area.

In addition to survey and mind-map analyses, the study also includes analyses of Twitter feeds in order to provide a basis to compare the survey and the mind-map approach (Kumar, Morstatter, and Liu, 2013). Statistical assessments are conducted.

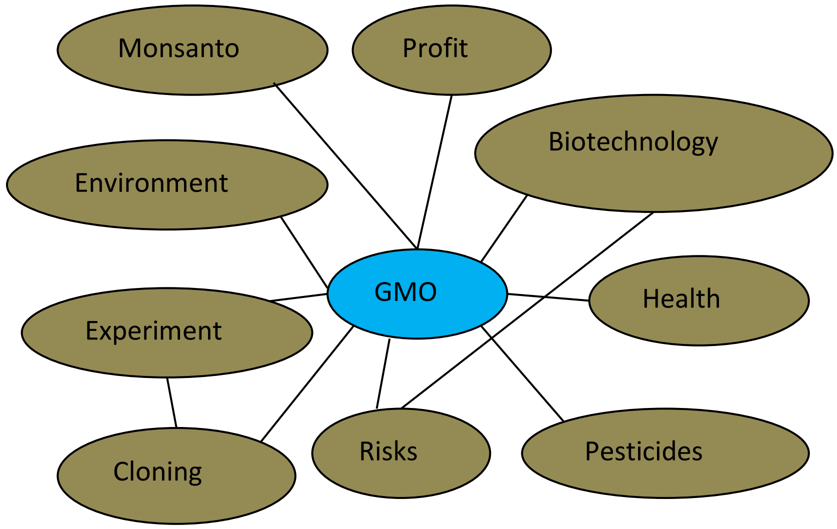

Figure 38. A mind-map illustration depicting interconnections among the term *GMO* and related terms

The remainder of this paper is organized as follows. Section 7.4 discusses the relevant background research for the study. Section 7.5 presents the objectives as well as the research questions and hypotheses. Section 7.6 provides an overview of the Experimental Setup. In Section 7.7, we present the performance Results and Analysis, and in Section 7.8, we present our conclusions and describe the ongoing future work.

7.4. Background and Context

There has been considerable research about GM foods and the mixed opinions regarding such biotechnologies. It is common for individuals to be strongly biased towards a view that GM foods are harmful and risky while others hold the view that GMOs provide benefits, such as improving the quality of crops and food products, and providing good traits (Persley and Siedow, 1999).

To measure attitudes about the potential benefits and/or risks involved with GM foods, there is some precedence in using survey-based research techniques (Moon, Balasubramanian, and Rimal, 2006). Our study is more detailed in terms of the evaluated factors, such as questions directly involving trust, ethics, and the environment. We also evaluate viewpoints about the risk itself. Other studies have targeted the monetary issues that people consider. One such study (Bugbee and Loureiro, 2003) evaluated consumers' purchasing attitudes about GM foods; the authors produced a theoretical model by developing an equation-based approach to address the issue. Their original model was extended by Han (2006); he collected consumers' responses using a survey-based approach for a single impact factor that was similar to the previous study.

A typical approach to measure risk perceptions is based on formulating explanatory models rather than data analytics. We are not aware of any prior work that directly applies a cognitive or visual approach, such as mind maps, to the issues as we did in Dass, O'Connor, and Schumate (2015). Most work with mind maps using tools such as MindMeister (Beel and Langer, 2011) have focused on basic exploratory analyses rather than network-based analyses. Within the survey and the associated mind maps, we included several novel and key aspects, or impact factors, pertaining to the study, such as those that pertain to human health, the environment, the economy, ethics, and trust in both GM institutions and the government.

In addition to the survey and mind-map work, we also analyzed the opinions of people who are socially active on Twitter. By extracting tweet sets, storing them in a database, parsing them, and carrying out analytics on them, we obtained a basis for comparison with the survey and mind-map work. There are many studies that extract Twitter feeds and then conduct a sentiment and/or opinion analysis based on those

Twitter feeds. (O’Connor et al., 2010) devised a strategy to map the entire tweet’s text as a sentiment and formulated public opinions based on those sentiments. Agarwal and Sabharwal (2012) focused on extracting and analyzing a single tweet and its followers, and devised a robust strategy to conduct a sentiment analysis. In our study, in addition to extracting a set of Twitter feeds that consist of people’s opinions about GMOs, we extracted relevant keywords from individual tweets and conducted analyses that were directed at understanding those opinions. This approach brought novelty to our study because prior studies about GM foods did not utilize sentiment or opinion analysis. Little prior work has been done with dictionary formulation followed by extracting and keywords from specific tweets in order to classify them and to carry out a sentiment or opinion analysis. There has, essentially, been no work done to evaluate the differences in gender viewpoints regarding GM foods.

7.5. Research Objectives

A key aspect of the study concerns changes in consumers’ perceptions about GM foods after pertinent information is provided. Essentially, the investigation evaluates whether consumers tend to modify their prior opinions about GM foods when they are exposed to informational materials that describe the benefits and risks of GM foods.

7.5.1. Design Instruments

We design a detailed questionnaire using the Qualtrics Survey API (“Qualtrics API”, 2016) and administered the survey online. This questionnaire consisted of basic demographic questions, such as age, ethnicity, education level, and salary information, as well as a set of pre-study and post-study questions related to GM foods and the effects of their presence in known food products. In addition, the questionnaire included two recent news releases that highlighted both the positive and negative aspects of GMOs (“Commission authorizes”, 2015; “GMO inside”, 2015). These news releases formed an interface between the pre-study and post-study questions. The first news release highlighted the adoption of a variety of GM crops, such as maize and soybeans, that were declared safe by the European Union (EU). Such authorizations are valid for 10 years. The second news release covered an announcement about two Hershey’s chocolate products (milk chocolate and kisses) to be GMO free and so-labeled by the end of that year. This decision was a result of a campaign by GMO Inside that had run for two years.

7.5.2. Research question and hypothesis

The following research question and hypothesis were formulated for this study.

Research Question: Does gender play a role in forming people’s perceptions about GMOs?

Hypothesis: When asked about GMOs, males tend to speak negatively about them when compared to females.

7.6. Experimental Setup

We describe the detailed setup for the mind-map study. All survey participants were recruited uniformly within the United States via the Amazon Mechanical Turk API (Amazon Mechanical Turk API, 2016). Each participant was asked to complete the pre-study survey questionnaire, followed by being asked to read the two news releases. The post-study questionnaire, with the same questions, was then completed. Each pre-study and post-study question consisted of multiple statements that described the effects of GM foods as well as their impact factors related to health, the environment, the economy, ethics, and trust. Both GM food corporations and government institutions are responsible for conducting and approving research involving GM foods. Each participant rated every statement on a 5-point Likert scale (5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; and 1: Strongly Disagree).

A related study by the authors (Dass et al., 2015) categorized survey responses by U.S. state of residence, and was based on multiple criteria to formulate and analyze various research questions and hypotheses.

7.7. Results and Analysis

This section provides a detailed analysis of the quantitative data, including the participants' recorded responses. This section is organized around the hypothesis formulated in Section 7.5.2. All the mind maps were created using NodeXL (Hansen, Shneiderman, and Smith, 2010) version 2014 and all the edge-weight values were normalized within the interval (0, 1). An alpha value of 0.05 was used for all statistical analyses conducted with SAS version 9.3.

For the Twitter study, feeds were extracted from the Twitter-streaming API (Kumar, Morstatter, and Liu, 2013). Experiments were conducted to evaluate the proposed research questions and hypotheses through the categorization of survey responses by gender. Positive and negative opinions about GMOs are calculated along with the user's gender in Twitter feeds. This reveals information about the role of gender about GMO perception in Twitter feeds.

7.7.1. Analysis using mind maps

A total of 446 participants, 183 males (41.03%) and 246 females (55.03%), from across the United States participated in the study. The mind maps were constructed using the procedure described in (Dass et al., 2015). Figures 39 and 40 plot a detailed comparison of the pre-study and post-study responses that were collected from the male and female participants when they were asked whether they thought GM foods were risky for their families. The plots were generated using the actual counts from the response ratings on a 5-point Likert scale in increasing order of *agreement* (*Not at all:* Strongly Disagree; *Slightly:* Disagree; *Moderately:* Neutral; *Very:* Agree; and *Extremely:* Strongly Agree), and the respective percentage values were obtained from the generated mind maps.

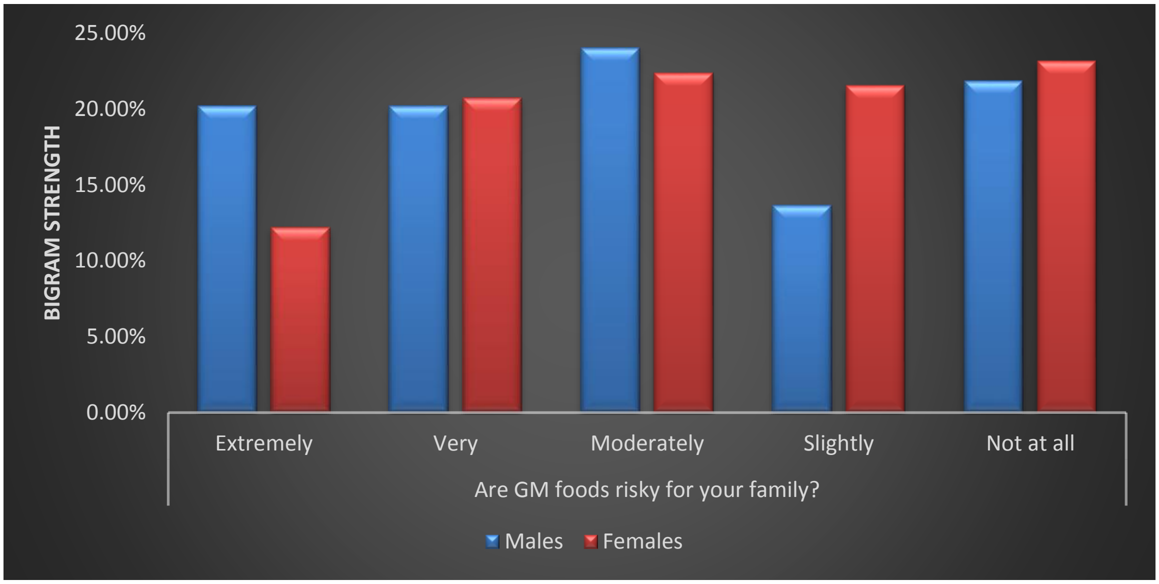

Figure 39. Pre-study analysis of the responses from males and females when they were asked “Are GM foods risky for your family?”

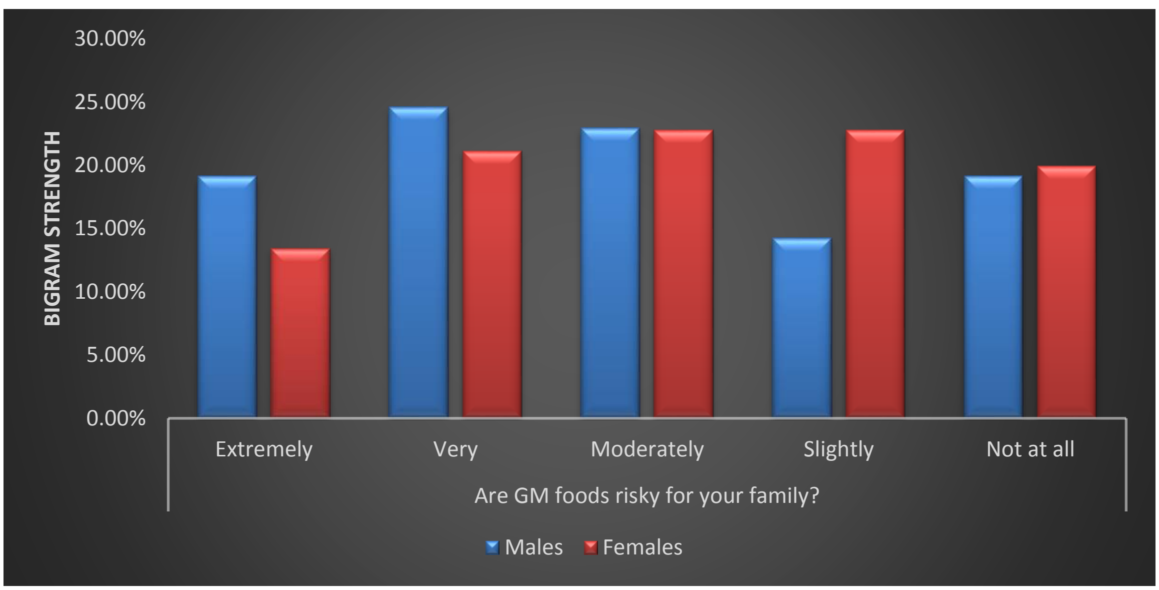

Figure 40. Post-study analysis of the responses from males and females when they were asked “Are GM foods risky for your family?”

From these figures, we infer that the male participants possessed slightly more negative viewpoints about GM foods when compared to their female counterparts and that males tended to consider GMOs to be extremely risky for their families. For the related survey questions, we consistently obtained similar results.

7.7.1.1. Statistical analysis of the survey results

To validate the results obtained with the mind-map technique, we conducted a thorough statistical analysis. Figures 41 and 42 provide the plots for the two-sample t-tests for the pre- and post-study responses for the same question that was described in Figures 39 and 40. Note that the 5-point, Likert-scale values are plotted in coded form on the bottom axis (Values from 1 through 5 are in increasing order of *agreement*).

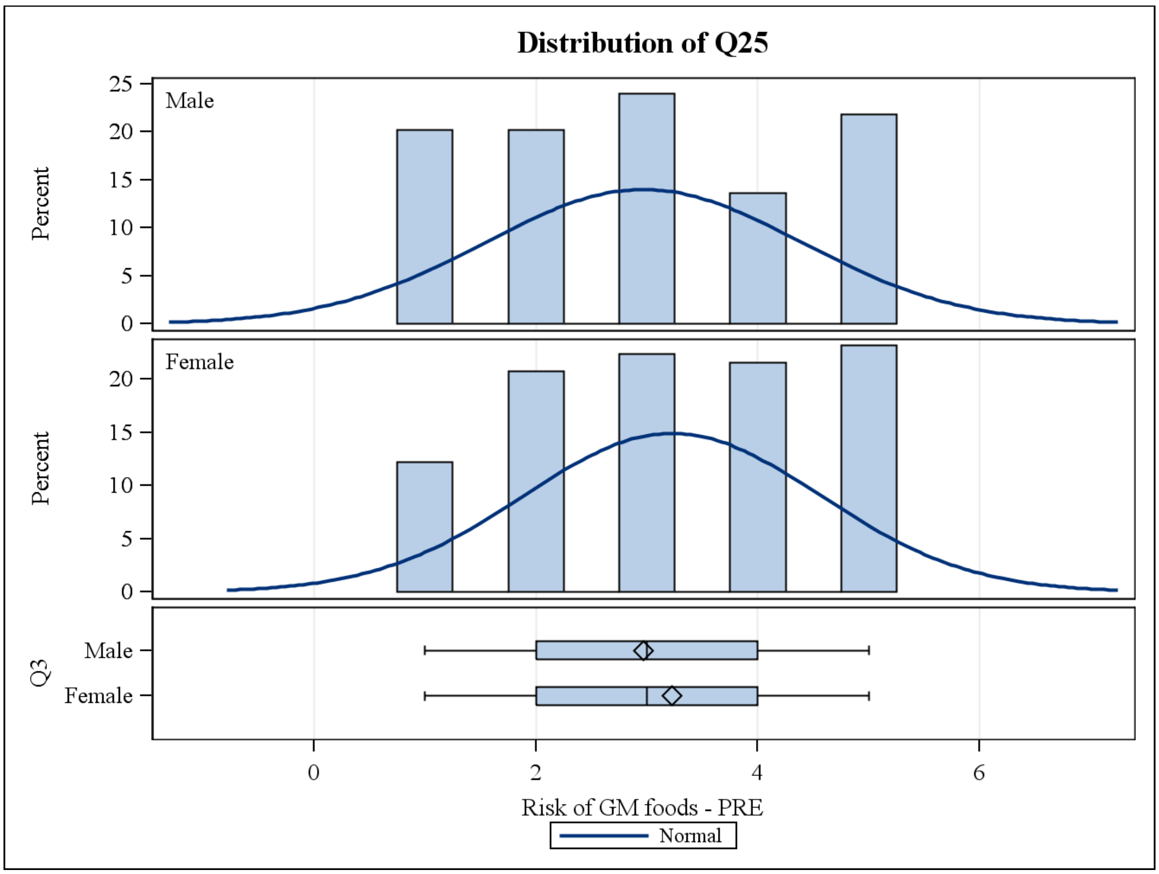

Figure 41. Pre-study distribution for Q. 25 (In your opinion, are GM foods risky for your family?)

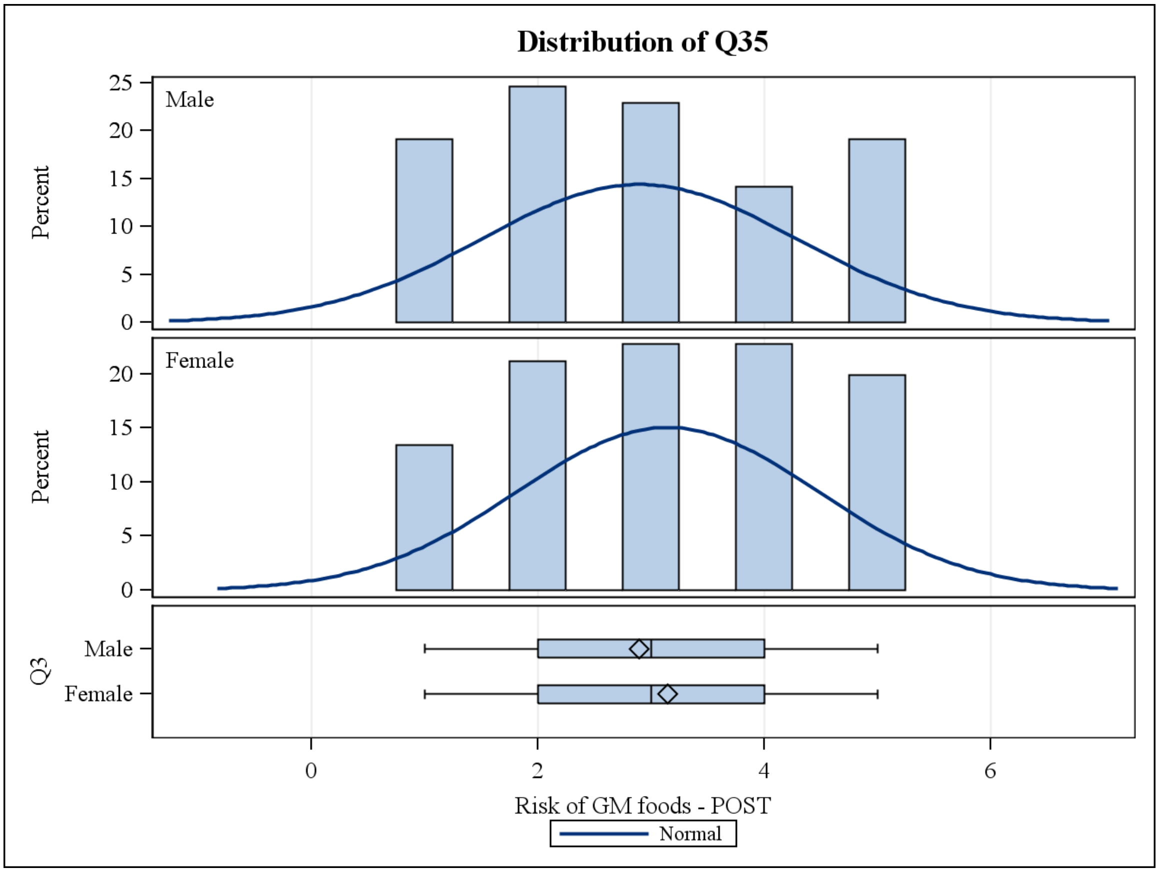

Figure 42. Post-study distribution for Q. 35 (In your opinion, are GM foods risky for your family?)

The t-test distributions show the mean responses for the male and female participants (horizontal bars located at the bottom of the distributions). We can see slight, but significant, differences in the mean responses (p = 0.0053) of Figure 41 for both groups and can infer that, when compared to the *females*, the *males* have more reserved opinions, and the males tend to think that consuming GM foods can be risky for their families. A similar explanation can also be given for the mean responses (p = 0.0059) from Figure 42. This validates our hypothesis from the statistical point of view.

7.7.2. Analysis with Twitter feeds

We extracted 7,557 Twitter feeds from the streaming API (Kumar, Morstatter, and Liu, 2013) using the search keyword *GMO* during a two-day period from August 24, 2015, to August 25, 2015. To compare our mind-map analysis results from Section 5.1 with the data obtained from the Twitter API, we began by categorizing the extracted Twitter feeds by gender using a language-independent package called *genderizer* (version 0.1.2.3), written in Python (Genderizer in Python, 2016). The program categorizes a person's gender by analyzing the given (or first) names of people in their Twitter handles (or usernames). If the package fails to successfully detect or classify the gender, then it data mines the sample text in the tweet using a naïve Bayes classifier (Rish, 2001). Proceeding in this manner, the software detected 2,254 (29.83%) male tweets and 2,589 (34.26%) female Tweets. The *genderizer* routine does not guarantee 100% accuracy, and in our work, it failed to classify 2,543 (33.65%) of the tweets.

Using *genderizer*, we determined that some tweets posted by the same person were classified as both male and female, resulting in a false positive. To account for such false positives in the classification scheme, we devised a majority-voting mechanism. The classified tweet (either male or female) which possessed a majority for that Twitter handle was declared the winner, and all that person's tweets were classified according to that majority. The tweets that could not be classified as either male or female were discarded.

Then, we extracted useful keywords related to GMOs (both positive and negative) from each tweet by matching the text in a tweet with the words and/or phrases in two extensive lists containing about 2,006 positive words and 4,783 negative words

(Hu and Liu, 2004). We constructed two lists, one consisting of all the extracted positive words and another consisting of all the extracted negative words, for both the male and female tweets. This action resulted in producing 520 total positive and 364 total negative words for both sets of tweets. We divided these two lists further by gender, resulting in 123 positive and 227 negative words for all the male tweets; likewise, there were 397 positive and 137 negative words for all the female tweets.

We conducted a chi-square statistical test to determine the association between gender and the nature of the GMO tweet. For analysis purposes, we identified about 884 unique Twitter handles that had at least one positive tweet, at least one negative tweet, and both. We excluded those Twitter handles which did not have any positive or negative tweet. Of the 884 unique Twitter handles, 350 (39.59%) were males and 534 (60.41%) were females. Figure 43 illustrates the domination of negative opinions over positive opinions in all the male tweets and Figure 44 compares the percentages of negative opinions for GMOs in all male and all female tweets.

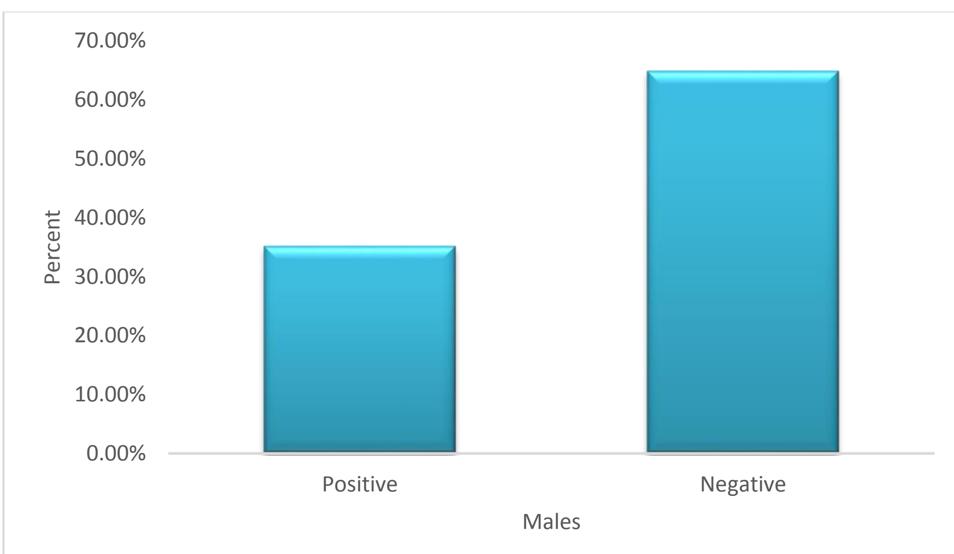

Figure 43. Percentage of positive and negative opinions for GMOs in all the male tweets

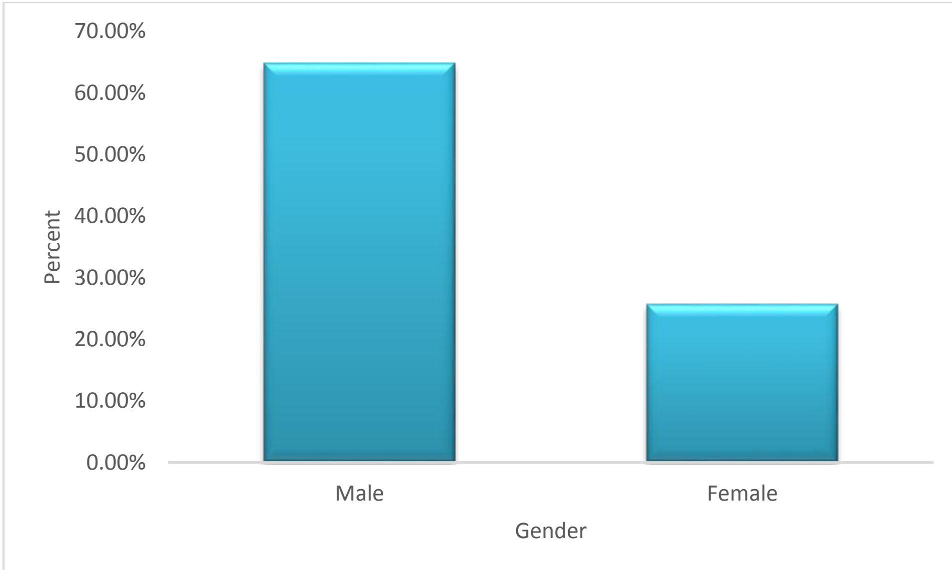

Figure 44. Percentage of negative opinions for GMOs in both the male and female tweets

By looking at Figures 43 and 44, we can easily infer that males possess more negative opinions about GMOs when compared to females. Also, from the chi-square test results ($p < 0.0001$), we can infer that there is a strong association between gender and the nature of the tweets such that males have more negative tweets than females. This again validates our proposed hypothesis in Section 7.5.2.

7.8. Conclusion and Future Work

In this study, we developed an approach to understand people's risk perceptions about GMOs using two techniques: one using mind maps and another extracting Twitter feeds. We designed an online survey that collected both pre-study and post-study responses from the participants regarding various effects with the presence of GMOs in food products, such as health, the environment, the economy, etc. We formulated a research question about people's gender based on the collected responses. Then, we tested the related hypothesis by conducting a relevant analysis to generate mind maps and validated the results with a statistical analysis. We further strengthened our analysis by conducting a comparison analysis using Twitter feeds. Our findings established that the *male participants* considered GM foods risky for their families when compared to the *female participants*.

In addition to categorizing the collected survey responses' data by gender, there are other possible categorizations, based on people's purchasing attitudes, which can lead to new results from the data. In the future, we plan to evaluate the use of mind maps for other purposes, such as computing the connections and flows across a mind-map network, clustering the network into dense modules, and assigning the concept of champion nodes to the modules. This applies promising data-mining and machine-learning techniques to analyze the results. We also plan to extend our Twitter-analysis techniques to conduct relevant sentiment and/or opinion analysis on a larger set of extracted Twitter feeds. We expect that applying these techniques will produce new and interesting results.

CHAPTER 8. CONCLUSION AND FUTURE WORK

In this research, we conducted an online survey that collected both pre- and post-study responses from the participants across the entire United States; we measured changes in their perceptions after reading news releases about GMOs. We analyzed these responses based on impact factors, such as health, the environment, ethics, government, and etc. We formulated research questions and hypotheses based on people's regional locations; their states' predominant political-party affiliation; and other demographic information, including gender, age, marital status, and education level. We tested these hypotheses by conducting statistical assessments and generating mind maps to measure the changes in participants' perceptions.

We drew our conclusions based on the assumptions for this research. One of the challenges associated with our research was selecting text-only news releases with the same length, format, and font size. Condensing the news releases for the survey would not have conveyed a different meaning to the respondents and, in turn, might not have provided a kind of bias towards a perception. Longer news releases might not be good for a participant to concentrate on his/her responses, and might consume more time and annoy him/her, which might interfere with survey completion. Because we did not randomize the order of the news releases in the survey, it might have influenced a bias towards a perception and, in turn, influenced the participants' responses.

We deduced that people from the *southern* region of the United States responded more positively about GMOs when compared to people who lived in the *north-east*, *western, and mid-west* regions. Also, we found that there was no significant difference in people's perceptions about GMOs based on *Democrat/non-partisan* and

Republican party-affiliated states in the United States. We further found that *male* participants from the entire United States responded more negatively about GM foods when compared to the *female* participants. We then compared and contrasted our results with the findings obtained by conducting the same survey with a group of computer science students at North Dakota State University; we found that the students responded more positively about GMOs when compared to the general-population participants. Additionally, we conducted the same survey with a relatively small group of participants from general population with the distinction that they did not read any news releases, thus serving as a *control group* for the general-population participants who responded earlier. We deduced that these participants seemed very reluctant to change their responses and there were very minute or negligible changes in their perceptions when compared with the previous participant group, thereby highlighting the impact of news releases.

Although we designed the survey in a twofold manner, pre- and post- study GMO-related issues, however, to have conducted the survey in a different manner, such as by altering the order of the news releases or by changing the news releases' format, may have a different outcome. Sometimes, even the length of the news releases may invoke a different thought process with people's mindset in terms of the seriousness towards the responses. There may be several other factors, such as marital status, ethnic background, purchasing habits, etc., which might influence the final outcome. We believe that, despite these differences, the impact on the overall outcome of the respondents' opinion changes would not be of much relevance.

In the future, we plan to evaluate the use of mind maps for other purposes, such as computing the connections and flows across a mind-map network, clustering the network into dense modules, and assigning the concept of champion nodes to the modules. This applies promising data-mining and machine-learning techniques to analyze the results. We also plan to extend the Twitter-analysis techniques to conduct sentiment and/or opinion analysis with a large set of extracted Twitter feeds and then to measure the gender differences regarding the observed opinions and sentiments. In addition to categorizing the collected survey responses' data by state of residence and gender, there are other interesting categorizations, based on age, marital status, number of children living in the household, and consumers' purchasing attitudes, which can lead to new results. We expect that applying these techniques will produce new and interesting results.

REFERENCES

1) A. Agarwal and J. Sabharwal. End-to-end sentiment analysis of twitter data. In proceedings of the workshop on Information Extraction and Entity Analytics on Social Media Data at the 24th International Conference on Computational Linguistics (IEEASMD-COLING ’12), 2012.

2) Amazon Mechanical Turk (Mturk) API. Retrieved at http://docs.aws.amazon.com/AWSMechTurk/latest/AWSMechanicalTurkGettingStartedGuide/amt-gsg.pdf (Accessed: 13 February 2016).

3) Are GMOs in food safe? Retrieved at https://www.mindmeister.com/35868401/are-gmo-s-in-food-safe (Accessed: 12 February 2016).

4) G. Baker and T. Burnham. Consumer response to genetically modified foods: Market segment analysis and implications for producers and policy makers. Journal of Agricultural and Resource Economics, Volume 26, Issue 2, 2001, pp. 387-403.

5) G. Baker and M. Mazzocco. Consumer response to GMO foods: Branding, certification, and consumer characteristics. AAEA-WAEA Annual Meeting, Long Beach, California, USA, 2002.

6) J. Beel, B. Gipp and J. Stiller. Information retrieval on mind maps – What could it be good for? In proceedings of the 5th International Conference on Collaborative Computing: Networking, Applications and Worksharing (CollaborateCom ’09), IEEE, Washington D.C., 2009, pp. 1-4.

7) J. Beel and S. Langer. An exploratory analysis of mind maps. In proceedings of the 11th ACM Symposium on Document Engineering (DocEng ‘11), New York, USA, 2011, pp. 81-84.

8) M. Bugbee and M. Loureiro. A risk perception analysis of genetically modified foods based on stated preferences. Agricultural and Applied Economics Association Annual Meeting, Montreal, Canada, 2003.

9) M. Burton and D. Pearse. Consumer attitudes towards genetic modification, functional foods, and microorganisms: A choice modeling experiment for beer. AgBioForum, Volume 5, Issue 2, 2002, pp. 51-58.

10) M. Burton, D. Rigby, T. Young and S. James. Consumer attitudes to genetically modified organisms in food in the UK. European Review of Agricultural Economics, Volume 28, Issue 4, 2001, pp. 479-498.

11) T. Buzan. The mind map book. BBC Books, 2nd edition, London, England, 1995.

12) M. Chernick. The essentials of biostatistics for physicians, nurses and clinicians. Wiley, 2011.

13) Commission authorises 17 GMOs for food/feed uses and 2 GM carnations. Brussels, 24 April 2015. Retrieved at http://europa.eu/rapid/press-release_IP-15-4843_en.htm (Accessed: 13 December 2015).

14) K. Crammer and Y. Singer. Pranking with ranking. In Advances in Neural Information Processing Systems (NIPS), 2001, pp. 641-647.

15) J. Cronbach. Coefficient alpha and the internal structure of tests. Psychometrika, Volume 16, Issue 3, 1951, pp. 297-334.

16) P. Dass, M. Chowdhury, D. Lampl and K. Nygard. Risk perceptions for genetically modified organisms: An empirical study. In proceedings of International Symposium on Software Engineering and Applications (SEA ’15), Marina Del Rey, California, USA, 2015.

17) P. Dass, Y. Lu, M. Chowdhury, D. Lampl, J. Kamalanathan and K. Nygard. Gender differences in perceptions of genetically modified foods. To appear in proceedings of 31st International Conference on Computers and their Applications (CATA ’16), Las Vegas, Nevada, USA, 2016.

18) P. Dass, A. O’Connor and M. Schumate. Collaborative research: Mind mapping consumers and activists’ response to NGO-corporate partnerships using Brand Associative Network Diagrams (BrANDi) tool, Technical report, 2015.

19) M. Finucane and J. Holup. Psychosocial and cultural factors affecting the perceived risk of genetically modified food: An overview of the literature. Social Science and Medicine, Volume 60, Elsevier, 2005, pp. 1603-1612.

20) C. Frey. “Mind mapping software user survey”. Retrieved at http://mindmappingsoftwareblog.com/2010-survey-form (Accessed: 31 January 2016).

21) G. Gaskell, P. Thompson and N. Allum. Worlds apart? Public opinion in Europe and the USA. In M. Bauer and G. Gaskell (eds.) Biotechnology: The making of a global controversy, Cambridge University Press, Cambridge, UK, 2002, pp. 351-376.

22) Genderizer in Python. Retrieved at https://pypi.python.org/pypi/genderizer (Accessed: 13 February 2016).

23) D. George and P. Mallery. SPSS for Windows step by step: A simple guide and reference. 11.0 update (4th edition), Allyn & Bacon, Boston, Massachusetts, 2002.

24) Glossary of negative words related to genetically modified organisms. Retrieved at http://www.enchantedlearning.com/wordlist/negativewords.shtml (Accessed: 31 January 2016).

25) Glossary of positive words related to genetically modified organisms. Retrieved at http://www.enchantedlearning.com/wordlist/positivewords.shtml (Accessed: 31 January 2016).

26) GMO inside announces victory for consumers: Hershey's milk chocolate and kisses to go non-GMO by the end of 2015. Washington, February 23, 2015. Retrieved at http://www.prnewswire.com/news-releases/gmo-inside-announces-victory-for-consumers-hersheys-milk-chocolate-and-kisses-to-go-non-gmo-by-the-end-of-2015-300039934.html (Accessed: 13 February 2016).

27) J. Han. The effects of perceptions on consumer acceptance of genetically modified (GM) foods. Dissertation, 2006.

28) D. Hansen, B. Shneiderman and M. Smith. Analyzing social media networks with NodeXL: Insights from a connected world. Morgan Kaufmann, 2010.

29) M. Hu and B. Liu. Mining and summarizing customer reviews. In proceedings of the 10th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining (KDD '04), Seattle, Washington, USA, 2004, pp. 168-177.

30) D. Jonassen. Computers in the classroom: Mindtools for critical thinking. Merrill, 1996.

31) D. Jonassen, K. Beissner, and M. Yacci. Structural knowledge: Techniques for representing, conveying and acquiring structural knowledge. Routledge, 1993.

32) D. Jonassen, C. Carr and H. Yueh. Computers as mindtools for engaging learners in critical thinking. TechTrends, Volume 43, Issue 2, 1998, pp. 24-32.

33) C. Kaempf. Biohazards related to genetically modified organisms (GMOs): A call for a visuals-supported discourse on environmental impact. In proceedings of

International Conference on Professional Communication Conference (IPCC ’05), 2005, pp. 266-273.

34) D. Knuth. The art of computer programming: Fundamental algorithms. Addison-Wesley Professional, 3rd edition, 1997.

35) S. Kumar, F. Morstatter and H. Liu. Twitter data analytics. Springer, New York, New York, USA, 2013.

36) A. Kvanli, R. Pavur and K. Keeling. Concise managerial statistics. Cengage Learning, 2005.

37) N. Millis. Genetically modified organisms. Department of Environment and Heritage (paper prepared for the 2006 Australian State of the Environment Committee), Canberra, 2006.

38) N. Mishra, R. Schreiber, I. Stanton and R. Tarjan. Clustering social networks. In workshop on Algorithms and Models for the Web-Graph (WAW ’07), San Diego, California, USA, 2007, pp. 56-67.

39) W. Moon, S. Balasubramanian and A. Rimal. WTP and WTA for non-GM and GM food: UK consumers. Agricultural and Applied Economics Association Annual Meeting, Long Beach, California, USA, 2006.

40) W. Morley and S. Seneff. Diminished brain resilience syndrome: A modern day neurological pathology of increased susceptibility to mild brain trauma, concussion, and downstream neurodegeneration. Surgical Neurology International, Volume 5, 97, 2014.

41) C. Nunnally. Assessment of reliability. Psychometric theory, 2nd edition, McGraw-Hill, New York, New York, USA, 1978.

42) B. O'Connor, R. Balasubramanyan, B. Routledge and N. Smith. From tweets to polls: Linking text sentiment to public opinion time series. In proceedings of 4th International AAAI Conference on Weblogs and Social Media (ICWSM '10), Washington, USA, 2010.

43) B. Onyango, R. Nayga, Jr. and R. Govindasamy. U.S. consumers' willingness to pay for food labelled "genetically modified". Journal of Agricultural and Resource Economics Review, Volume 35, Issue 2, 2006, pp. 299-310.

44) G. Persley and J. Siedow. Application of biotechnology to crops: Benefits and risks. Council for Agricultural Science and Technology. Washington, 1999.

45) N. Pidgeon, W. Poortinga, et al. Using surveys in public participation processes for risk decision making: The case of the 2003 British GM Nation? Public debate. Risk Analysis, Volume 25, Issue 2, 2005, pp. 467-479.

46) Qualtrics API. Retrieved at http://www.qualtrics.com (Accessed: 13 February 2016).

47) I. Rish. An empirical study of the naïve Bayes classifier. In proceedings of IJCAI-01 workshop on empirical methods in AI, Sicily, Italy, 2001, pp. 41-46.

48) S. Roller and S. Harlander. Genetic modification in the food industry: A strategy for food quality improvement. Blackie Academic & Professional, 1998.

49) L. Savadori, S. Savio, et al. Expert and public perception of risk from biotechnology. Risk Analysis, Volume 24, Issue 5, 2004, pp. 1289-1299.

50) B. Snyder and R. Barzilay. Multiple aspect ranking using the good grief algorithm. In proceedings of the Joint Conference of the North American Chapter of the Association for Computational Linguistics and Human Language Technologies, 2007, pp. 300-307.

51) S. Takeda and M. Matsouka. Genetic approaches to crop improvement: Responding to environmental and population changes. Nature Reviews Genetics, Volume 9, 2008, pp. 444-457.

52) J. Thomas and R. Fuchs. Biotechnology and safety assessment. Academic Press, 3rd edition, 2002.

53) P. Thompson. Is the GMO controversy related to computer ethics? ACM Ubiquity Magazine, Volume 2008, Issue January, Article No. 2, New York, USA, 2008.

54) P. Turney. Thumbs up or thumbs down? Semantic orientation applied to unsupervised classification of reviews. In proceedings of 40th Annual Meeting of the Association for Computational Linguistics (ACL), Philadelphia, Pennsylvania, 2002, pp. 417-424.

55) United States political parties' affiliation map. August 6, 2009. Retrieved at https://www.commons.wikimedia.org/wiki/File:Map_of_USA_by_state_upperhouse.svg (Accessed: 13 February 2016).

56) United States regions map according to US Census Bureau. November 14, 2014. Retrieved at http://www.mapsofworld.com/usa/usa-maps/united-states-regional-maps.html (Accessed: 13 February 2016).

57) D. Whitman. Genetically modified foods: Harmful or helpful? ProQuest, 2000.

58) Who invented mind mapping. Retrieved at https://www.mind-mapping.org/mindmapping-learning-study-memory/who-invented-mind-mapping.html (Accessed: 30 January 2016).

59) C. Willis and S. Miertschin. Mind maps as active learning tools. Journal of Computing Sciences in Colleges, Volume 21, Issue 4, 2006, pp. 266-272.

APPENDIX A. SURVEY QUESTIONNAIRE

Q1 The purpose of this research project is to understand the perceptions of consumers toward food products that involve biotechnology such as genetically modified organisms (GMO). This is a research project being conducted at the Department of Computer Science in North Dakota State University, Fargo, ND, USA.

Your participation in this research study is voluntary. You may choose not to participate. If you decide to participate in this research survey, you may withdraw at any time. If you decide not to participate in this study or if you withdraw from participating at any time, you will not be penalized. The procedure involves filling an online survey that will take approximately 20 to 25 minutes. Your responses will be confidential and we will not collect identifying information such as your name, email address or IP address. Your anonymity will be protected at all times and your responses will be kept confidential. The results of this study will be used solely for scholarly purposes.

If you have any questions about this research study, please contact Dr. Kendall Nygard at kendall.nygard@ndsu.edu. This research has been reviewed according to North Dakota State University IRB procedures for research involving human subjects.

ELECTRONIC CONSENT: Please select your choice below. Clicking on the "Agree" button below indicates that:

• you have read and understood the above information

• you voluntarily agree to participate

If you do not wish to participate in the research study, please decline participation by clicking on the "Disagree" button.

- Agree
- Disagree

Q2 What is your state of residence?

- Alabama
- Alaska
- Arizona
- Arkansas
- California
- Colorado
- Connecticut
- Delaware
- Florida
- Georgia
- Hawaii
- Idaho
- Illinois
- Indiana
- Iowa
- Kansas
- Kentucky
- Louisiana
- Maine

- Maryland
- Massachusetts
- Michigan
- Minnesota
- Mississippi
- Missouri
- Montana
- Nebraska
- Nevada
- New Hampshire
- New Jersey
- New Mexico
- New York
- North Carolina
- North Dakota
- Ohio
- Oklahoma
- Oregon
- Pennsylvania
- Rhode Island
- South Carolina
- South Dakota
- Tennessee

- Texas
- Utah
- Vermont
- Virginia
- Washington
- West Virginia
- Wisconsin
- Wyoming
- District of Columbia
- Puerto Rico
- Guam
- American Samoa
- U.S. Virgin Islands
- Northern Mariana Islands

Q3 What is your gender?

- Male
- Female
- Undisclosed

Q4 Please select an age group you belong to.

- 18 - 24
- 25 - 39
- 40 - 54
- 55 or above
- Undisclosed

Q5 What is your ethnicity?

- White
- Hispanic or Latino
- Black or African American
- Native American or American Indian
- Asian/Pacific Islander
- Undisclosed

Q6 How many children and/or dependents (not including yourself) live in your household?

- 0
- 1-2
- 3-5
- 6 or more

Q7 What is your highest education level?

- Doctoral Degree or Equivalent
- Master's Degree
- Bachelor's Degree
- College/Associate Degree
- High School Diploma or Equivalent
- Other or Undisclosed

Q8 What is your marital status?

- Single or Never Married
- Married or Domestic Partnership
- Widowed
- Divorced
- Separated
- Undisclosed

Q9 What is your current employment status?

- Employed for wages
- Self-employed
- Out of work and looking for work
- Out of work but not currently looking for work
- Student
- Homemaker
- Military
- Retired
- Unable to work
- Undisclosed

Q10 Are you primarily responsible for purchasing groceries for your household?

- Yes
- No

Q11 What proportion of your household income goes into purchasing groceries?

- ❍ 0-9%
- ❍ 10-24%
- ❍ 25-49%
- ❍ 50% or more
- ❍ Don't know

Q12 How often do you shop for groceries?

- ❍ Daily
- ❍ Two to Three Times a Week
- ❍ Once a Week
- ❍ Two to Three Times a Month
- ❍ Once a Month

Q13 Where do you shop for groceries? (Check all that apply.)

- ❑ Supermarket
- ❑ General Store
- ❑ Street Vendor
- ❑ Farmer's Market
- ❑ Deli
- ❑ Delivery to Home
- ❑ Other

Q14 How familiar are you with the term GMO (Genetically Modified Organisms)?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

Q15 What is your primary source of information about GMO?

- Newspapers/Magazines/Other Print Media
- TV/Radio
- Internet/Social Media
- Family/Friends
- Other or Not Applicable

Q16 In your opinion, what could be the health effects of GMO?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Provides medicinal remedies	❍	❍	❍	❍	❍
Enhances nutritional value	❍	❍	❍	❍	❍
Requires few artificial preservatives	❍	❍	❍	❍	❍
Reduces use of pesticides	❍	❍	❍	❍	❍
Causes diseases or allergies	❍	❍	❍	❍	❍
Are toxic or poisonous	❍	❍	❍	❍	❍
Causes nutrient imbalances	❍	❍	❍	❍	❍
Accumulates harmful substances in body	❍	❍	❍	❍	❍

Q17 In your opinion, what could be the environmental safety effects of GMO?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Provides resistance to crop pests	❍	❍	❍	❍	❍
Causes soil degradation	❍	❍	❍	❍	❍
Creates superweeds and superbugs	❍	❍	❍	❍	❍
Causes ecological imbalance	❍	❍	❍	❍	❍

Q18 In your opinion, what could be the ethical factors of GMO?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Conflicts with nature	❍	❍	❍	❍	❍
Creates moral concerns over research	❍	❍	❍	❍	❍
Causes unknown adverse effects over time	❍	❍	❍	❍	❍

Q19 In your opinion, what could be the trust factors associated with GMO biotechnology institutions?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Provides accurate safety information	❍	❍	❍	❍	❍
Provides accurate nutritional information	❍	❍	❍	❍	❍
Provides accurate scientific information	❍	❍	❍	❍	❍

Q20 In your opinion, what could be the trust factors associated with government institutions?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Provides accurate safety information	❍	❍	❍	❍	❍
Provides accurate nutritional information	❍	❍	❍	❍	❍
Provides accurate scientific information	❍	❍	❍	❍	❍

Q21 What factors convince you that genetically modified foods are safe? (Check all that apply.)

❑ Science

❑ Government

❑ Media

❑ Celebrity

❑ Personal Belief

❑ Other or Undisclosed

Q22 What factors convince you that genetically modified foods are not safe? (Check all that apply.)

- ❑ Science
- ❑ Government
- ❑ Media
- ❑ Celebrity
- ❑ Personal Belief
- ❑ Other or Undisclosed

Q23 In your opinion, how important are the following factors for purchasing genetically modified foods?

	Extremely	Very	Moderately	Slightly	Not at all
Taste	❍	❍	❍	❍	❍
Price	❍	❍	❍	❍	❍
Quality	❍	❍	❍	❍	❍
Availability	❍	❍	❍	❍	❍
Safety	❍	❍	❍	❍	❍

Q24 In your opinion, how safe are the following GMO commodities?

	Extremely	Very	Moderately	Slightly	Not at all
Corn	❍	❍	❍	❍	❍
Soy	❍	❍	❍	❍	❍
Cotton	❍	❍	❍	❍	❍
Papaya	❍	❍	❍	❍	❍
Rice	❍	❍	❍	❍	❍
Canola	❍	❍	❍	❍	❍
Potato	❍	❍	❍	❍	❍
Tomato	❍	❍	❍	❍	❍
Dairy Product	❍	❍	❍	❍	❍
Peas	❍	❍	❍	❍	❍

Q25 In your opinion, how risky do you think GM foods can be for your family?

❍ Extremely

❍ Very

❍ Moderately

❍ Slightly

❍ Not at all

Q26 Now you will read the following two news stories about genetically modified foods' safety.

Associated Press Newswire - April 24, 2015

European Commission authorizes 17 GMO's for food/feed uses and 2 GM carnations, Brussels, Belgium - The Commission today adopted 10 new authorizations for Genetically Modified Organisms (GMO's) for food/feed use, 7 renewals of existing authorizations and also the authorization for the importation of 2 GMO cut flowers (not for food or feed). These GMO's had gone through a full authorization procedure, including a favorable scientific assessment by the European Food Safety Authority (EFSA).

All the GMO's approved today have been proved to be safe before their placing on the EU market. The risk assessment has been done by EFSA in collaboration with Member States for each individual GMO to be put on the market. The GM food and feed authorizations will be added to the existing list of 58 GMO's authorized in the EU for food and feed uses (covering maize, cotton, soybean, sugar beet). The authorizations are valid for 10 years, and any products produced from these GMO's will be subject to the EU's labeling and traceability rules.

Associated Press Newswire - February 23, 2015

GMO Inside Announces Victory for Consumers: Hershey's Milk Chocolate and Kisses to Go Non-GMO by the End of 2015, Washington, USA - In response to tens of thousands of Facebook posts, emails, and telephone calls from consumers who took part in GMO Inside's campaign calling on Hershey's to move to non-GMO ingredients, the U.S. chocolate giant released a statement last week that it will feature a lineup of simple ingredients, and transition some of its most popular chocolate brands, including Hershey's Kisses Milk Chocolates and Hershey's Milk Chocolate Bars to simpler ingredients. Today, Hershey's confirmed that as part of its commitment to simpler ingredients, its two iconic products will be non-GMO by the end of the year.

Green America Food Campaigns Director, Nicole McCann, stated: We congratulate Hershey's on this important move and great first step. As one of the leading chocolate companies in the U.S., this commitment will help move the rest of the companies in this sector. Hershey's joins General Mills, Unilever, Post Foods, and other leading companies in responding to consumer demand to make at least some of its products non-GMO. Hershey's needs to take the next step and go non-GMO with all of its chocolates, and get third-party verification for non-GMO ingredients. This includes sourcing milk from cows not fed GMOs and agreeing to prohibit any synthetic biology ingredients, starting with vanilla, stated John Roulac, co-chair of GMO Inside - Consumers are increasingly looking for non-GMO products and verification, and Hershey's and its competitors would be wise to offer third-party verified non-GMO products to consumers.

Q27 Now that you have read the above news stories, please answer the questions that follow. You will notice that some of the questions are being repeated from above. The responses to these questions are necessary knowing that you have now gained some knowledge about genetically modified organisms and confirms your completion of this study. If you decide not to answer these questions or if you withdraw at this time, your responses will not be recorded and you will not be penalized.

Q28 In your opinion, what could be the health effects of GMO?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Provides medicinal remedies	❍	❍	❍	❍	❍
Enhances nutritional value	❍	❍	❍	❍	❍
Requires few artificial preservatives	❍	❍	❍	❍	❍
Reduces use of pesticides	❍	❍	❍	❍	❍
Causes diseases or allergies	❍	❍	❍	❍	❍
Are toxic or poisonous	❍	❍	❍	❍	❍
Causes nutrient imbalances	❍	❍	❍	❍	❍
Accumulates harmful substances in body	❍	❍	❍	❍	❍

Q29 In your opinion, what could be the environmental safety effects of GMO?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Provides resistance to crop pests	❍	❍	❍	❍	❍
Causes soil degradation	❍	❍	❍	❍	❍
Creates superweeds and superbugs	❍	❍	❍	❍	❍
Causes ecological imbalance	❍	❍	❍	❍	❍

Q30 In your opinion, what could be the ethical factors of GMO?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Conflicts with nature	❍	❍	❍	❍	❍
Creates moral concerns over research	❍	❍	❍	❍	❍
Causes unknown adverse effects over time	❍	❍	❍	❍	❍

Q31 In your opinion, what could be the trust factors associated with GMO biotechnology institutions?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Provides accurate safety information	❍	❍	❍	❍	❍
Provides accurate nutritional information	❍	❍	❍	❍	❍
Provides accurate scientific information	❍	❍	❍	❍	❍

Q32 In your opinion, what could be the trust factors associated with government institutions?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Provides accurate safety information	❍	❍	❍	❍	❍
Provides accurate nutritional information	❍	❍	❍	❍	❍
Provides accurate scientific information	❍	❍	❍	❍	❍

Q33 In your opinion, how important are the following factors for purchasing genetically modified foods?

	Extremely	Very	Moderately	Slightly	Not at all
Taste	❍	❍	❍	❍	❍
Price	❍	❍	❍	❍	❍
Quality	❍	❍	❍	❍	❍
Availability	❍	❍	❍	❍	❍
Safety	❍	❍	❍	❍	❍

Q34 In your opinion, how safe are the following GMO commodities?

	Extremely	Very	Moderately	Slightly	Not at all
Corn	❍	❍	❍	❍	❍
Soy	❍	❍	❍	❍	❍
Cotton	❍	❍	❍	❍	❍
Papaya	❍	❍	❍	❍	❍
Rice	❍	❍	❍	❍	❍
Canola	❍	❍	❍	❍	❍
Potato	❍	❍	❍	❍	❍
Tomato	❍	❍	❍	❍	❍
Dairy Product	❍	❍	❍	❍	❍
Peas	❍	❍	❍	❍	❍

Q35 In your opinion, how risky do you think GM foods can be for your family?

❍ Extremely

❍ Very

❍ Moderately

❍ Slightly

❍ Not at all

Q36 After completing this survey, will you seek more information on genetically modified foods' safety?

- ❍ Yes
- ❍ No
- ❍ Don't know

APPENDIX B. NEWS RELEASES

B.1. European Union (EU) News Release

European Commission - Press release

Commission authorises 17 GMOs for food/feed uses and 2 GM carnations

Brussels, 24 April 2015

The Commission today adopted 10 new authorisations for Genetically Modified Organisms (GMOs) for food/feed use, 7 renewals of existing authorisations and also the authorisation for the importation of 2 GMO cut flowers (not for food or feed). These GMOs had gone through a full authorisation procedure, including a favourable scientific assessment by the European Food Safety Authority (EFSA). The authorisation decisions do not cover cultivation.

The GMOs approved today had received "no opinion" votes from Member States in both the Standing and Appeal Committees, since no qualified majority either in favour or against was expressed. The Commission adopted these pending decisions, as required by the current GMO legal framework. Authorisations were not granted during the past months whilst a review of the decision making procedure on GMO authorisations was ongoing. The outcome of that review was presented on April 22 with the adoption of a communication reviewing the process for the authorisation of Genetically Modified Organisms (GMOs) and a legislative proposal in order to amend Regulation 1829/2003 on food and feed (IP/15/4777, MEMO/15/4778 and MEMO/15/4779). Until the new proposal will be adopted by Parliament and Council, the authorisations process has to be based on the current applicable legislative framework.

All the GMOs approved today have been proved to be safe before their placing on the EU market. The risk assessment has been done by EFSA in collaboration with Member States for each individual GMO to be put on the market. The GM food and feed authorisations will be added to the existing list of 58 GMOs authorised in the EU for food and feed uses (covering maize, cotton, soybean, oilseed rape, sugar beet).

The authorisations are valid for 10 years, and any products produced from these GMOs will be subject to the EU's labelling and traceability rules.

The GMO's adopted today are as follows:

- 10 new authorisations: MON 87460 maize, MON 87705 soybean, MON 87708 soybean, MON 87769 soybean, 305423 soybean, BPS-CV127-9 soybean, MON 88302, oilseed rape, T304-40 cotton, MON 88913 cotton, LLCotton25xGHB614 cotton
- 7 renewals: T25 maize, NK603 maize, GT73 oilseed rape, MON 531 x MON 1445 cotton, MON 15985 cotton; MON 531 cotton and MON 1445 cotton

- 2 GM cut flowers (carnations line IFD-25958-3 and line IFD-26407-2).

The list of authorised GM plants and the precise scope of their authorisation is available in the EU register of GM food and feed, which can be found here: http://ec.europa.eu/food/dyna/gm_register/index_en.cfm

For more information: http://ec.europa.eu/food/plant/gmo/index_en.htm
IP/15/4843

B.2. GMO Inside and Green America News Release

GMO Inside Announces Victory for Consumers: Hershey's Milk Chocolate and Kisses to Go Non-GMO by the End of 2015

Latest Move by Hershey's Follows the Removal of GMOs by General Mills, Unilever, Post Foods.

Feb 23, 2015, 16:30 ET from GMO Inside and Green America

WASHINGTON, Feb. 23, 2015 /PRNewswire-USNewswire/ -- In response to tens of thousands of Facebook posts, emails, and telephone calls from consumers who took part in GMO Inside's campaign calling on Hershey's to move to non-GMO ingredients, the U.S. chocolate giant released a statement last week (http://www.thehersheycompany.com/newsroom/news-release.aspx?id=2017846) that it "will feature a lineup of simple ingredients, and transition some of its most popular chocolate brands, including Hershey's Kisses Milk Chocolates and Hershey's Milk Chocolate Bars to simpler ingredients."

Today, Hershey's confirmed that as part of its commitment to simpler ingredients, its two iconic products will be non-GMO by the end of the year.

Green America Food Campaigns Director Nicole McCann stated: "**We congratulate Hershey's on this important move and great first step. As one of the leading chocolate companies in the U.S., this commitment will help move the rest of the companies in this sector. Hershey's joins General Mills, Unilever, Post Foods, and other leading companies in responding to consumer demand to make at least some of its products non-GMO."**

Two years ago, in February 2013, GMO Inside began calling on consumers to put pressure on Hershey's (as well Mars) to make its products without GMOs due to concerns over the environmental and health impacts of GMOs (http://gmoinside.org/hershey-mars/). In response, thousands of consumers emailed the company urging it to remove GMOs.

In December 2014, when Hershey's announced it was exploring transitioning away from high fructose corn syrup (HFCS), GMO Inside mobilized consumers to call the company to urge it not to use any other form of GMO sugar, such as from GMO sugar beets (http://greenam.org/1Bfmbre); and then again in February 2015 called on consumers to post on the company's Facebook page on Valentine's Day (http://gmoinside.org/hersheys-show-us-love-organic-sugar/).

"Hershey's needs to take the next step and go non-GMO with all of its chocolates, and get third-party verification for non-GMO ingredients. This includes sourcing milk from cows not fed GMOs and agreeing to prohibit any synthetic biology ingredients, starting with vanilla," stated John Roulac, co-chair of GMO Inside. "Consumers are increasingly looking for non-GMO products and verification, and Hershey's and its competitors would be wise to offer third-party verified non-GMO products to consumers."

ABOUT GMO INSIDE

GMO Inside is a campaign dedicated to helping all Americans know which foods have GMOs inside; and removing GMOs and toxins from our food supply. We believe that everyone has a right to know what's in their food and to choose foods that are proven safe for people, their families, and the environment. GMO Inside provides the information for a growing community of people from all walks of life, to make informed decisions around genetically engineered foods. Join the campaign at www.gmoinside.org, and take part in the GMO Inside community on Facebook and Twitter.

ABOUT GREEN AMERICA

Green America is the nation's leading green economy organization. Founded in 1982, Green America (formerly Co-op America) provides the economic strategies, organizing power and practical tools for businesses, investors, and individuals to solve today's social and environmental problems (http://www.greenamerica.org).

SOURCE GMO Inside and Green America

RELATED LINKS

http://gmoinside.org/

http://www.greenamerica.org/

APPENDIX C. FREQUENCY TABLES FOR GENERAL-POPULATION PARTICIPANTS

Table C1. Comparison of pre- and post-study frequency values for question statement "Provides medicinal remedies" for the general-population participants

Q16a (Provides medicinal remedies: PRE)	Q28a (Provides medicinal remedies: POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	13	13	2	6	3	37
Agree	12	77	14	15	2	120
Neutral	5	35	50	22	4	116
Disagree	0	16	12	70	47	145
Strongly Disagree	0	4	1	17	6	28
Total	30	145	79	130	62	446

Table C2. Comparison of pre- and post-study frequency values for question statement "Enhances nutritional value" for general population participants

Q16b(Enhances nutritional value - PRE)	Q28b(Enhances nutritional value - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	7	4	3	0	0	14
Agree	9	75	20	16	6	126
Neutral	2	50	63	33	3	151
Disagree	2	9	13	71	34	129
Strongly Disagree	0	1	1	19	5	26
Total	20	139	100	139	48	446

Table C3. Comparison of pre- and post-study frequency values for question statement "Requires few artificial preservatives" for general population participants

Q16c(Requires few artificial preservatives - PRE)	Q28c(Requires few artificial preservatives - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	8	7	4	2	1	22
Agree	3	73	23	14	2	115
Neutral	1	48	71	30	5	155
Disagree	0	6	12	74	35	127
Strongly Disagree	1	1	2	18	5	27
Total	13	135	112	138	48	446

Table C4. Comparison of pre- and post-study frequency values for question statement "Reduces use of pesticides" for general population participants

Q16d(Reduces use of pesticides - PRE)	Q28d(Reduces use of pesticides - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	6	7	4	2	0	19
Agree	6	70	14	15	2	107
Neutral	6	35	91	32	4	168
Disagree	1	7	11	71	38	128
Strongly Disagree	0	0	1	18	5	24
Total	19	119	122	137	49	446

Table C5. Comparison of pre- and post-study frequency values for question statement "Causes diseases or allergies" for general population participants

Q16e(Causes diseases or allergies - PRE)	Q28e(Causes diseases or allergies - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	4	15	17	0	0	36
Agree	4	42	30	3	0	79
Neutral	6	43	143	41	3	236
Disagree	1	9	27	39	10	86
Strongly Disagree	0	1	2	4	2	9
Total	15	110	219	87	15	446

Table C6. Comparison of pre- and post-study frequency values for question statement "Are toxic or poisonous" for general population participants

Q16f(Are toxic or poisonous - PRE)	Q28f(Are toxic or poisonous - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	5	9	23	0	0	37
Agree	4	36	31	3	0	74
Neutral	3	44	147	40	2	236
Disagree	0	8	28	45	11	92
Strongly Disagree	0	0	2	3	2	7
Total	12	97	231	91	15	446

Table C7. Comparison of pre- and post-study frequency values for question statement “Causes nutrient imbalances” for general population participants

Q16g(Causes nutrient imbalances - PRE)	Q28g(Causes nutrient imbalances - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	5	7	23	1	0	36
Agree	8	32	29	3	0	72
Neutral	9	41	141	46	4	241
Disagree	1	11	25	38	9	84
Strongly Disagree	0	2	3	4	4	13
Total	23	93	221	92	17	446

Table C8. Comparison of pre- and post-study frequency values for question statement “Accumulates harmful substances in body” for general population participants

Q16h(Accumulates harmful substances in body - PRE)	Q28h(Accumulates harmful substances in body - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	4	9	24	2	1	40
Agree	10	42	30	5	0	87
Neutral	4	36	127	42	4	213
Disagree	3	13	25	43	11	95
Strongly Disagree	0	1	5	2	3	11
Total	21	101	211	94	19	446

Table C9. Comparison of pre- and post-study frequency values for question statement “Provides resistance to crop pests” for general population participants

Q17a(Provides resistance to crop pests - PRE)	Q29a(Provides resistance to crop pests - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	9	8	5	0	1	23
Agree	9	72	20	15	5	121
Neutral	4	36	91	27	2	160
Disagree	2	5	20	55	10	92
Strongly Disagree	1	0	28	16	5	50
Total	25	121	164	113	23	446

Table C10. Comparison of pre- and post-study frequency values for question statement “Causes soil degradation” for general population participants

Q17b(Causes soil degradation - PRE)	Q29b(Causes soil degradation - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	3	8	1	0	0	12
Agree	12	57	29	13	1	112
Neutral	6	27	145	36	4	218
Disagree	0	12	30	41	8	91
Strongly Disagree	1	0	4	1	7	13
Total	22	104	209	91	20	446

Table C11. Comparison of pre- and post-study frequency values for question statement “Creates superweeds and superbugs” for general population participants

Q17c(Creates superweeds and superbugs - PRE)	**Q29c(Creates superweeds and superbugs - POST)**					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	3	5	1	1	1	11
Agree	7	64	30	6	0	107
Neutral	4	36	135	37	6	218
Disagree	1	13	27	49	8	98
Strongly Disagree	1	0	3	1	7	12
Total	16	118	196	94	22	446

Table C12. Comparison of pre- and post-study frequency values for question statement “Causes ecological imbalance” for general population participants

Q17d(Causes ecological imbalance - PRE)	**Q29d(Causes ecological imbalance - POST)**					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	6	6	0	2	1	15
Agree	8	53	33	8	1	103
Neutral	4	38	133	32	3	210
Disagree	1	10	27	52	10	100
Strongly Disagree	0	2	4	4	8	18
Total	19	109	197	98	23	446

Table C13. Comparison of pre- and post-study frequency values for question statement “Conflicts with nature” for general population participants

Q18a(Conflicts with nature - PRE)	Q30a(Conflicts with nature - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	8	13	5	2	1	29
Agree	15	87	30	9	0	141
Neutral	8	32	125	26	3	194
Disagree	0	17	9	35	8	69
Strongly Disagree	0	0	1	4	8	13
Total	31	149	170	76	20	446

Table C14. Comparison of pre- and post-study frequency values for question statement “Creates moral concerns over research” for general population participants

Q18b(Creates moral concerns over research - PRE)	Q30b(Creates moral concerns over research - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	6	13	6	2	0	27
Agree	15	75	33	9	0	132
Neutral	8	36	122	27	4	197
Disagree	5	16	9	38	7	75
Strongly Disagree	0	0	1	5	9	15
Total	34	140	171	81	20	446

Table C15. Comparison of pre- and post-study frequency values for question statement "Causes unknown adverse effects over time" for general population participants

Q18c(Causes unknown adverse effects over time - PRE)	Q30c(Causes unknown adverse effects over time - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	7	9	6	2	0	24
Agree	9	77	27	7	1	121
Neutral	10	46	120	22	4	202
Disagree	5	22	15	36	7	85
Strongly Disagree	0	0	1	4	9	14
Total	31	154	169	71	21	446

Table C16. Comparison of pre- and post-study frequency values for question statement "Provides accurate safety information (GM Institutions)" for general population participants

Q19a(Provides accurate safety information - PRE)	Q31a(Provides accurate safety information - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	23	17	13	1	0	54
Agree	21	134	37	5	1	198
Neutral	10	49	107	8	1	175
Disagree	1	5	5	3	0	14
Strongly Disagree	1	2	0	0	2	5
Total	56	207	162	17	4	446

Table C17. Comparison of pre- and post-study frequency values for question statement "Provides accurate nutritional information (GM Institutions)" for general population participants

Q19b(Provides accurate nutritional information - PRE)	Q31b(Provides accurate nutritional information - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	13	14	5	0	0	32
Agree	22	137	41	6	2	208
Neutral	13	58	110	6	0	187
Disagree	2	3	7	2	0	14
Strongly Disagree	0	3	0	0	2	5
Total	50	215	163	14	4	446

Table C18. Comparison of pre- and post-study frequency values for question statement "Provides accurate scientific information (GM Institutions)" for general population participants

Q19c(Provides accurate scientific information - PRE)	Q31c(Provides accurate scientific information - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	10	10	6	0	0	26
Agree	28	127	42	4	1	202
Neutral	19	64	109	6	1	199
Disagree	5	3	5	2	0	15
Strongly Disagree	0	2	0	0	2	4
Total	62	206	162	12	4	446

Table C19. Comparison of pre- and post-study frequency values for question statement "Provides accurate safety information (Government Institutions)" for general population participants

Q20a(Provides accurate safety information - PRE)	Q32a(Provides accurate safety information - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	20	23	9	0	0	52
Agree	24	152	37	6	0	219
Neutral	10	46	96	3	1	156
Disagree	1	3	5	6	0	15
Strongly Disagree	0	2	0	0	2	4
Total	55	226	147	15	3	446

Table C20. Comparison of pre- and post-study frequency values for question statement "Provides accurate nutritional information (Government Institutions)" for general population participants

Q20b(Provides accurate nutritional information - PRE)	Q32b(Provides accurate nutritional information - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	13	26	9	0	1	49
Agree	27	150	31	3	0	211
Neutral	4	55	106	3	2	170
Disagree	1	1	4	4	0	10
Strongly Disagree	1	2	1	0	2	6
Total	46	234	151	10	5	446

Table C21. Comparison of pre- and post-study frequency values for question statement "Provides accurate scientific information (Government Institutions)" for general population participants

Q20c(Provides accurate scientific information - PRE)	Q32c(Provides accurate scientific information - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	15	23	7	1	0	46
Agree	23	141	37	4	1	206
Neutral	12	48	102	6	2	170
Disagree	1	3	10	6	0	20
Strongly Disagree	1	1	0	0	2	4
Total	52	216	156	17	5	446

APPENDIX D. FREQUENCY TABLES FOR STUDENTS

Table D1. Comparison of the pre- and post-study frequency values for question statement "Provides medicinal remedies" for students

Q18_1 (Provides medicinal remedies: PRE)	Q26_1 (Provides medicinal remedies: POST)				
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Total**
Strongly Agree	7	1	0	0	8
Agree	0	20	7	3	30
Neutral	1	1	14	1	17
Disagree	0	3	2	7	12
Strongly Disagree	0	0	1	1	2
Total	8	25	24	12	69

Table D2. Comparison of pre- and post-study frequency values for question statement “Enhances nutritional value” for students

Q18_2(Enhances nutritional value - PRE)	Q26_2(Enhances nutritional value - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	5	3	0	0	0	8
Agree	1	25	6	1	0	33
Neutral	1	3	9	1	0	14
Disagree	0	3	3	5	0	11
Strongly Disagree	0	0	0	1	2	3
Total	7	34	18	8	2	69

Table D3. Comparison of pre- and post-study frequency values for question statement “Requires few artificial preservatives” for students

Q18_3(Requires few artificial preservatives - PRE)	Q26_3(Requires few artificial preservatives - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	5	3	0	1	0	9
Agree	1	26	2	2	0	31
Neutral	1	6	9	2	2	20
Disagree	0	3	2	4	0	9
Total	7	38	13	9	2	69

Table D4. Comparison of pre- and post-study frequency values for question statement “Reduces use of pesticides” for students

Q18_4(Reduces use of pesticides - PRE)	Q26_4(Reduces use of pesticides - POST)				
Frequency	Strongly Agree	Agree	Neutral	Disagree	Total
Strongly Agree	10	4	0	2	16
Agree	1	27	2	2	32
Neutral	0	1	7	0	8
Disagree	0	5	2	6	13
Total	11	37	11	10	69

Table D5. Comparison of pre- and post-study frequency values for question statement “Causes diseases or allergies” for students

Q18_5(Causes diseases or allergies - PRE)	Q26_5(Causes diseases or allergies - POST)				
Frequency	Agree	Neutral	Disagree	Strongly Disagree	Total
Agree	9	6	3	0	18
Neutral	2	12	4	0	18
Disagree	3	6	14	2	25
Strongly Disagree	0	0	2	6	8
Total	14	24	23	8	69

Table D6. Comparison of pre- and post-study frequency values for question statement "Are toxic or poisonous" for students

Q18_6(Are toxic or poisonous - PRE)	Q26_6(Are toxic or poisonous - POST)				
Frequency	Agree	Neutral	Disagree	Strongly Disagree	Total
Agree	6	1	3	0	10
Neutral	4	13	1	0	18
Disagree	1	4	25	2	32
Strongly Disagree	0	0	1	8	9
Total	11	18	30	10	69

Table D7. Comparison of pre- and post-study frequency values for question statement "Causes nutrient imbalances" for students

Q18_7(Causes nutrient imbalances - PRE)	Q26_7(Causes nutrient imbalances - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	1	0	0	0	0	1
Agree	0	9	2	3	0	14
Neutral	0	6	18	4	0	28
Disagree	0	3	1	15	1	20
Strongly Disagree	0	1	0	1	4	6
Total	1	19	21	23	5	69

Table D8. Comparison of pre- and post-study frequency values for question statement "Accumulates harmful substances in body" for students

Q18_8(Accumulates harmful substances in body - PRE)	Q26_8(Accumulates harmful substances in body - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	1	0	0	0	0	1
Agree	0	11	2	4	0	17
Neutral	0	3	16	3	0	22
Disagree	0	1	6	15	1	23
Strongly Disagree	0	0	0	0	6	6
Total	1	15	24	22	7	69

Table D9. Comparison of pre- and post-study frequency values for question statement "Provides resistance to crop pests" for students

Q19_1(Provides resistance to crop pests - PRE)	Q27_1(Provides resistance to crop pests - POST)				
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Total**
Strongly Agree	8	10	1	0	19
Agree	1	34	6	0	41
Neutral	0	2	5	0	7
Disagree	0	1	0	1	2
Total	9	47	12	1	69

Table D10. Comparison of pre- and post-study frequency values for question statement “Causes soil degradation” for students

Q19_2(Causes soil degradation - PRE)	Q27_2(Causes soil degradation - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	1	3	0	0	0	4
Agree	0	10	5	0	0	15
Neutral	0	4	23	3	0	30
Disagree	0	1	3	11	1	16
Strongly Disagree	0	0	0	1	3	4
Total	1	18	31	15	4	69

Table D11. Comparison of pre- and post-study frequency values for question statement “Creates superweeds and superbugs” for students

Q19_3(Creates superweeds and superbugs - PRE)	Q27_3(Creates superweeds and superbugs - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	2	2	0	0	0	4
Agree	1	24	0	2	0	27
Neutral	0	6	12	1	0	19
Disagree	0	2	3	11	0	16
Strongly Disagree	0	0	1	0	2	3
Total	3	34	16	14	2	69

Table D12. Comparison of pre- and post-study frequency values for question statement "Causes ecological imbalance" for students

Q19_4(Causes ecological imbalance - PRE)	Q27_4(Causes ecological imbalance - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	4	2	0	0	0	6
Agree	0	16	2	0	1	19
Neutral	1	5	18	3	0	27
Disagree	0	1	2	11	0	14
Strongly Disagree	0	0	0	1	2	3
Total	5	24	22	15	3	69

Table D13. Comparison of pre- and post-study frequency values for question statement "Conflicts with nature" for students

Q20_1(Conflicts with nature - PRE)	Q28_1(Conflicts with nature - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	5	4	0	0	0	9
Agree	3	21	2	2	0	28
Neutral	0	5	7	0	0	12
Disagree	0	1	1	13	1	16
Strongly Disagree	0	0	0	1	3	4
Total	8	31	10	16	4	69

Table D14. Comparison of pre- and post-study frequency values for question statement "Creates moral concerns over research" for students

Q20_2(Creates moral concerns over research - PRE)	Q28_2(Creates moral concerns over research - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	2	3	0	0	0	5
Agree	1	17	3	1	0	22
Neutral	0	7	10	3	0	20
Disagree	0	1	5	9	2	17
Strongly Disagree	0	0	0	1	4	5
Total	3	28	18	14	6	69

Table D15. Comparison of pre- and post-study frequency values for question statement "Causes unknown adverse effects over time" for students

Q20_3(Causes unknown adverse effects over time - PRE)	Q28_3(Causes unknown adverse effects over time - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	8	4	0	0	0	12
Agree	3	22	1	1	1	28
Neutral	0	1	14	5	0	20
Disagree	0	0	0	5	1	6
Strongly Disagree	0	0	0	1	2	3
Total	11	27	15	12	4	69

Table D16. Comparison of pre- and post-study frequency values for question statement "Provides accurate safety information (GM Institutions)" for students

Q21_1(Provides accurate safety information - PRE)	Q29_1(Provides accurate safety information - POST)				
Frequency	Strongly Agree	Agree	Neutral	Disagree	Total
Strongly Agree	5	0	0	0	5
Agree	3	37	3	3	46
Neutral	0	2	9	0	11
Disagree	0	1	0	6	7
Total	8	40	12	9	69

Table D17. Comparison of pre- and post-study frequency values for question statement "Provides accurate nutritional information (GM Institutions)" for students

Q21_2(Provides accurate nutritional information - PRE)	**Q29_2(Provides accurate nutritional information - POST)**				
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Total**
Strongly Agree	8	0	0	0	8
Agree	3	35	4	2	44
Neutral	0	2	8	1	11
Disagree	0	0	1	5	6
Total	11	37	13	8	69

Table D18. Comparison of pre- and post-study frequency values for question statement "Provides accurate scientific information (GM Institutions)" for students

Q21_3(Provides accurate scientific information - PRE)	**Q29_3(Provides accurate scientific information - POST)**				
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Total**
Strongly Agree	6	2	0	0	8
Agree	2	33	4	4	43
Neutral	0	1	6	1	8
Disagree	0	1	2	7	10
Total	8	37	12	12	69

Table D19. Comparison of pre- and post-study frequency values for question statement "Provides accurate safety information (Government Institutions)" for students

Q22_1(Provides accurate safety information - PRE)	Q30_1(Provides accurate safety information - POST)				
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Total**
Strongly Agree	7	1	1	0	9
Agree	2	30	2	1	35
Neutral	0	5	10	0	15
Disagree	0	0	1	9	10
Total	9	36	14	10	69

Table D20. Comparison of pre- and post-study frequency values for question statement "Provides accurate nutritional information (Government Institutions)" for students

Q22_2(Provides accurate nutritional information - PRE)	Q30_2(Provides accurate nutritional information - POST)				
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Total**
Strongly Agree	7	1	0	0	8
Agree	3	29	2	1	35
Neutral	0	2	9	4	15
Disagree	0	1	0	10	11
Total	10	33	11	15	69

Table D21. Comparison of pre- and post-study frequency values for question statement “Provides accurate scientific information (Government Institutions)” for students

Q22_3(Provides accurate scientific information - PRE)	Q30_3(Provides accurate scientific information - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	6	1	0	0	0	7
Agree	3	27	2	4	0	36
Neutral	0	2	12	1	0	15
Disagree	0	1	0	9	1	11
Total	9	31	14	14	1	69

Table D22. Comparison of pre- and post-study frequency values for question statement “Risk of GM foods” for students

Q23(Risk of GM foods - PRE)	Q31(Risk of GM foods - POST)					
Frequency	Extremely	Very	Moderately	Slightly	Not at all	Total
Extremely	1	0	0	0	0	1
Very	0	4	1	0	0	5
Moderately	0	1	15	1	0	17
Slightly	0	0	2	18	2	22
Not at all	0	0	1	3	20	24
Total	1	5	19	22	22	69

APPENDIX E. FREQUENCY TABLES FOR CONTROL-GROUP PARTICIPANTS

Table E1. Comparison of the pre- and post-study frequency values for question statement "Provides medicinal remedies" for the control-group participants

Q16a (Provides medicinal remedies: PRE)	Q28a (Provides medicinal remedies: POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	9	0	0	0	0	9
Agree	0	36	0	0	0	36
Neutral	1	0	16	1	0	18
Disagree	0	0	1	33	0	34
Strongly Disagree	0	0	0	0	9	9
Total	10	36	17	34	9	106

Table E2. Comparison of pre- and post-study frequency values for question statement "Enhances nutritional value" for control group participants

Q16b(Enhances nutritional value - PRE)	Q28b(Enhances nutritional value - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	5	1	0	0	0	6
Agree	0	33	1	0	0	34
Neutral	0	1	27	1	0	29
Disagree	0	0	0	28	0	28
Strongly Disagree	0	0	0	0	9	9
Total	5	35	28	29	9	106

Table E3. Comparison of pre- and post-study frequency values for question statement "Requires few artificial preservatives" for control group participants

Q16c(Requires few artificial preservatives - PRE)	Q28c(Requires few artificial preservatives - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	3	2	0	0	0	5
Agree	0	34	0	1	0	35
Neutral	0	1	30	0	0	31
Disagree	0	0	0	27	0	27
Strongly Disagree	0	0	0	0	8	8
Total	3	37	30	28	8	106

Table E4. Comparison of pre- and post-study frequency values for question statement "Reduces use of pesticides" for control group participants

Q16d(Reduces use of pesticides - PRE)	Q28d(Reduces use of pesticides - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	4	0	0	0	0	4
Agree	0	29	1	1	0	31
Neutral	0	1	34	0	0	35
Disagree	0	0	0	28	0	28
Strongly Disagree	0	0	0	0	8	8
Total	4	30	35	29	8	106

Table E5. Comparison of pre- and post-study frequency values for question statement "Causes diseases or allergies" for control group participants

Q16e(Causes diseases or allergies - PRE)	Q28e(Causes diseases or allergies - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	2	0	0	0	0	2
Agree	0	20	0	0	0	20
Neutral	0	0	66	1	0	67
Disagree	0	1	0	15	0	16
Strongly Disagree	0	0	0	0	1	1
Total	2	21	66	16	1	106

Table E6. Comparison of pre- and post-study frequency values for question statement "Are toxic or poisonous" for control group participants

Q16f(Are toxic or poisonous - PRE)	Q28f(Are toxic or poisonous - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	1	0	0	0	0	1
Agree	0	14	1	0	0	15
Neutral	0	0	67	1	0	68
Disagree	0	0	2	19	0	21
Strongly Disagree	0	0	0	0	1	1
Total	1	14	70	20	1	106

Table E7. Comparison of pre- and post-study frequency values for question statement “Causes nutrient imbalances” for control group participants

Q16g(Causes nutrient imbalances - PRE)	Q28g(Causes nutrient imbalances - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	1	1	0	0	0	2
Agree	0	20	0	0	0	20
Neutral	0	0	64	0	0	64
Disagree	0	1	1	15	0	17
Strongly Disagree	0	0	0	0	3	3
Total	1	22	65	15	3	106

Table E8. Comparison of pre- and post-study frequency values for question statement “Accumulates harmful substances in body” for control group participants

Q16h(Accumulates harmful substances in body - PRE)	Q28h(Accumulates harmful substances in body - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	3	1	0	0	0	4
Agree	0	24	1	0	0	25
Neutral	0	1	50	1	0	52
Disagree	1	2	1	18	0	22
Strongly Disagree	0	0	0	0	3	3
Total	4	28	52	19	3	106

Table E9. Comparison of pre- and post-study frequency values for question statement "Provides resistance to crop pests" for control group participants

Q17a(Provides resistance to crop pests - PRE)	Q29a(Provides resistance to crop pests - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	5	0	0	0	0	5
Agree	0	37	2	2	0	41
Neutral	1	0	22	0	0	23
Disagree	0	0	1	24	0	25
Strongly Disagree	0	0	0	1	11	12
Total	6	37	25	27	11	106

Table E10. Comparison of pre- and post-study frequency values for question statement "Causes soil degradation" for control group participants

Q17b(Causes soil degradation - PRE)	Q29b(Causes soil degradation - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	4	1	0	0	0	5
Agree	1	32	0	0	0	33
Neutral	0	1	46	0	0	47
Disagree	0	0	2	17	0	19
Strongly Disagree	0	0	0	0	2	2
Total	5	34	48	17	2	106

Table E11. Comparison of pre- and post-study frequency values for question statement "Creates superweeds and superbugs" for control group participants

Q17c(Creates superweeds and superbugs - PRE)	Q29c(Creates superweeds and superbugs - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	2	0	0	0	0	2
Agree	1	29	0	0	0	30
Neutral	0	0	50	1	0	51
Disagree	0	1	0	21	0	22
Strongly Disagree	0	0	0	0	1	1
Total	3	30	50	22	1	106

Table E12. Comparison of pre- and post-study frequency values for question statement "Causes ecological imbalance" for control group participants

Q17d(Causes ecological imbalance - PRE)	Q29d(Causes ecological imbalance - POST)					
Frequency	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Strongly Agree	2	0	0	0	0	2
Agree	1	28	0	0	0	29
Neutral	0	1	46	0	0	47
Disagree	0	1	1	24	0	26
Strongly Disagree	0	1	0	0	1	2
Total	3	31	47	24	1	106

Table E13. Comparison of pre- and post-study frequency values for question statement “Conflicts with nature” for control group participants

Q18a(Conflicts with nature - PRE)	Q30a(Conflicts with nature - POST)				
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Total**
Strongly Agree	15	1	0	0	16
Agree	0	44	2	0	46
Neutral	0	1	33	0	34
Disagree	0	1	0	9	10
Total	15	47	35	9	106

Table E14. Comparison of pre- and post-study frequency values for question statement “Creates moral concerns over research” for control group participants

Q18b(Creates moral concerns over research - PRE)	Q30b(Creates moral concerns over research - POST)					
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total**
Strongly Agree	13	1	0	0	0	14
Agree	0	40	0	0	0	40
Neutral	0	1	38	1	0	40
Disagree	0	1	0	10	0	11
Strongly Disagree	0	0	0	0	1	1
Total	13	43	38	11	1	106

Table E15. Comparison of pre- and post-study frequency values for question statement "Causes unknown adverse effects over time" for control group participants

Q18c(Causes unknown adverse effects over time - PRE)	Q30c(Causes unknown adverse effects over time - POST)				
Frequency	Strongly Agree	Agree	Neutral	Disagree	Total
Strongly Agree	12	0	0	0	12
Agree	0	36	2	0	38
Neutral	0	1	39	0	40
Disagree	0	2	0	14	16
Total	12	39	41	14	106

Table E16. Comparison of pre- and post-study frequency values for question statement "Provides accurate safety information (GM Institutions)" for control group participants

Q19a(Provides accurate safety information - PRE)	Q31a(Provides accurate safety information - POST)				
Frequency	Strongly Agree	Agree	Neutral	Disagree	Total
Strongly Agree	26	0	0	0	26
Agree	0	50	2	0	52
Neutral	0	1	25	0	26
Disagree	0	0	0	2	2
Total	26	51	27	2	106

Table E17. Comparison of pre- and post-study frequency values for question statement "Provides accurate nutritional information (GM Institutions)" for control group participants

Q19b(Provides accurate nutritional information - PRE)	Q31b(Provides accurate nutritional information - POST)				
Frequency	Strongly Agree	Agree	Neutral	Disagree	Total
Strongly Agree	13	1	0	0	14
Agree	0	59	0	0	59
Neutral	0	2	29	0	31
Disagree	0	0	0	2	2
Total	13	62	29	2	106

Table E18. Comparison of pre- and post-study frequency values for question statement "Provides accurate scientific information (GM Institutions)" for control group participants

Q19c(Provides accurate scientific information - PRE)	Q31c(Provides accurate scientific information - POST)				
Frequency	Strongly Agree	Agree	Neutral	Disagree	Total
Strongly Agree	10	0	0	0	10
Agree	2	59	1	0	62
Neutral	0	1	31	0	32
Disagree	0	0	0	2	2
Total	12	60	32	2	106

Table E19. Comparison of pre- and post-study frequency values for question statement "Provides accurate safety information (Government Institutions)" for control group participants

Q20a(Provides accurate safety information - PRE)	Q32a(Provides accurate safety information - POST)				
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Total**
Strongly Agree	24	1	1	0	26
Agree	0	55	2	0	57
Neutral	0	1	21	0	22
Disagree	0	0	0	1	1
Total	24	57	24	1	106

Table E20. Comparison of pre- and post-study frequency values for question statement "Provides accurate nutritional information (Government Institutions)" for control group participants

Q20b(Provides accurate nutritional information - PRE)	Q32b(Provides accurate nutritional information - POST)				
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Total**
Strongly Agree	15	2	0	0	17
Agree	0	55	2	0	57
Neutral	0	2	29	0	31
Disagree	0	0	0	1	1
Total	15	59	31	1	106

Table E21. Comparison of pre- and post-study frequency values for question statement "Provides accurate scientific information (Government Institutions)" for control group participants

Q20c(Provides accurate scientific information - PRE)	Q32c(Provides accurate scientific information - POST)				
Frequency	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Total**
Strongly Agree	20	0	0	0	20
Agree	1	48	3	0	52
Neutral	0	3	28	0	31
Disagree	0	0	0	3	3
Total	21	51	31	3	106

Table E22. Comparison of pre- and post-study frequency values for question statement "Risk of GM foods" for control group participants

Q25(Risk of GM foods - PRE)	Q35(Risk of GM foods - POST)					
Frequency	**Extremely**	**Very**	**Moderately**	**Slightly**	**Not at all**	**Total**
Extremely	16	0	0	0	0	16
Very	0	27	0	0	0	27
Moderately	0	0	24	0	0	24
Slightly	0	1	0	14	0	15
Not at all	0	0	0	0	24	24
Total	16	28	24	14	24	106