Hungry for Information: Exploring Public Perception of Nanotechnology Food Product Labeling using Conversational Settings

A THESIS
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

Jonathan M. Brown

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE

Jennifer Kuzma

May 2012

Acknowledgements

First, a significant amount of praise and thanks goes to my research advisor, academic advisor, and Chair of my thesis committee, Dr. Jennifer Kuzma at the Humphrey School of Public Affairs. Her guidance, knowledge, insight, support, and patience were invaluable throughout the entire research and paper-writing process. I have learned as much from her, if not more, as I have from this research itself. A notable thank you is also in order to Steve Kelley of the Humphrey School of Public Affairs and Dr. Gurumurthy Ramachandran of the School of Public Health for both serving on my thesis committee. I further give many thanks to Andrew Merrill, formerly of the Office of Measurement Services, for patiently coordinating and executing our data collection and data reporting.

Additionally, this work would not have been possible without the support from the National Science Foundation Nanoscale Interdisciplinary Research Teams (NIRT) Award SES-0709056, "Intuitive Toxicology and Public Engagement", with principle investigator Dr. David Berube of North Caroline State University, and co-principle investigators Dr. Kevin Elliot of the University of South Carolina, Dr. Pat J. Gehrke of the University of South Carolina, Dr. Jennifer Kuzma of the University of Minnesota, and Dr. Dietram Scheufele of the University of Wisconsin.

I also would be remiss to not acknowledge my Humphrey School friends and peers who saw and cheered me through the whole research and writing process with nothing but helpful support and encouragement.

Lastly, I must give the deepest of thanks to my parents, Susanne Williams and Robert Brown, for providing unending love and wisdom through countless emails, phone calls, and conversations taking place during the entirety of this thesis's creation.

Dedication

This thesis is happily dedicated to my parents, Susanne Williams and Robert Brown.

Abstract

Exploration of public perception of nanotechnology food products and their labeling has been limited thus far. Labeling perceptions in particular have been analyzed in few contexts, none of which focused on food labeling using a conversational setting. A significant research gap thus exists, especially as nanotechnology food product development rapidly expands. Seven focus groups were hosted in six U.S. cities in order to analyze public perception of food nanotechnology and labeling in dialogue settings. Key research issues for this analysis dealt with identifying the main themes present during the labeling topic portion of each focus group and the resulting implications for nanotechnology food product labeling policy. Focus group data were analyzed by coding statements across numerous themes and selecting main themes based on occurrence frequency. In-group worksheets and post-group surveys were also administered covering a range of nanotechnology food topics and were descriptively analyzed. Content analysis results, in conjunction with worksheet and post-survey data, reveal the public wants labeling but acknowledge that a label is not of much use unless nanotechnology education or outreach is conducted. Additionally, while most participants viewed labels from a risk information and consumer choice standpoint, no consensus was reached for the ideal content and characteristics of a nanotechnology label. An array of major themes, both directly related and unrelated to labeling, emerged during the labeling phase including perceived label purpose, consumer choice perception, regulation perception, skepticism, trust, and risk, among many others. These insights from conversational settings provide an important step in considering the complexities of public perception as they apply to crafting effective policy surrounding nanotechnology food products.

Table of Contents

List of Tables

List of Figures

Chapter I: Introduction

Nanotechnology, the manipulation of matter and creation of structures at the nanometer scale, is rapidly growing in numerous areas, including academia, the military, and both public and private sector R&D. Although researchers and organization leaders throughout these groups are essential drivers for advancement, consumers as a whole represent an equally important piece in nanotechnology's development. While consumers generally do not actively set public and private sector technology R&D goals, they are ultimately the end users of a significant portion of such R&D. As a testament to this, currently over 1,300 nanotechnology-based consumer products circulate the global marketplace with much expectation for market growth (PEN 2012). Such products span a wide array of categories from cosmetics and medical tools, to clothing and sporting equipment.

One product area with much investment and promise is food. Nanotechnology shows high potential for food innovations and the expansion of food science (Sanguansri and Augustin 2006). Broadly, nanotechnology food R&D includes the areas of food storage, safety, texture, flavor, nutrition, quality, and freshness, in addition to being applicable to all components of the food production chain (Kuzma and VerHage 2006; Kuzma *et al.*, 2008; Bouwmeester *et al.,* 2009; Buzby 2010; Chaudhry *et al.,* 2008; Farhang 2011). Although much of this R&D has yet to translate into concrete applications, the Project on Emerging Nanotechnologies product inventory lists 105 food and beverage products in its database that are currently available on the world product market, though this may be an

underestimate (Chun 2009). Regardless, the number of these products is expected to rapidly grow (Chaudhry *et al.*, 2008; House of Lords 2010), which is logical, given the large, though uncertain, amount of financial investments in nanotechnology food products' R&D (Berube 2006; Dudo *et al.*, 2011; Kuzma and VerHage 2006). Accordingly, in addition to products and R&D, media attention is also on the rise. Looking at the past 30 years, media coverage of nanotechnology in food grew substantially, with the exception of a slight drop over years 2006 through 2009 (Dudo *et al.*, 2011).

Given the clear continuing expansion of food processed with nanotechnology or made with nanomaterials and rising media attention, consumers will naturally become more exposed to such products and information about them. Consequently, since consumers are end users of food products, their perceptions of such products will grow increasingly important as the nanotechnology food product market grows. Logically, a market cannot develop and food nanotechnology investment will diminish if the public rejects or distrusts the outputs and institutions tied to food nanotechnology. As a result, not only will the public's acceptance, confidence, and trust affect the potential development of food nanotechnology (Buzby 2010; Chaudhry 2008; Dudo *et al.*, 2011), but nanotechnology's success as a key technology may well depend on the public's perceptions and resulting views and behavior (Köhler and Som 2008; Macoubrie 2006; Royal Society and Royal Academy of Engineering 2004). Moreover, ethical concerns are equally if not more important than economic and technological considerations. Engaging with public perception issues invokes important matters of consumers' rights (Throne-

Holst and Standbakken 2009), such as consumers' "right to know" and "right to choose" regarding nanotechnology products and information. Acknowledging public perception is a key component for ensuring the ethical and practical concerns of the public as a stakeholder in nanotechnology's development are addressed.

Food labels are one of the major aspects of food products with which the public interacts and that influences consumer behavior and perception. Notably, public perception of nanotechnology food product labels remains unexplored, save for a few studies where labeling emerged secondarily to a different aspect of food nanotechnology or was not the primary study focus (Burri and Bellucci 2008; Pidgeon and Rogers-Hayden 2007; Throne-Holst and Strandbakken 2009). Moreover, use of non-survey techniques for public perception of nanotechnology in general and across various applications pales in comparison to survey usage. Survey usage far outweighs non-survey usage in the literature, creating an abundance of descriptive and inferential statistics, but leaving a gap in deeper and more complex public thought and rationale. To unpack public perceptions in a way that is valuable for stakeholders involved in nanotechnology food products and labeling, the public included, applying open-ended and detail-rich non-survey techniques is essential.

In this paper, the topic of nanotechnology food product labeling is therefore explored through public perception obtained in a setting meant to elicit details and rationale not attainable with closed-ended survey methods. Chapter II reviews previous work on

public perception of nanotechnology in general and in food, including issues of labeling, and discusses detailed motivations for this study. Chapter III summarizes data collection and analysis methodologies and a data overview. Chapter IV presents quantitative results from focus group worksheet responses and the post-survey, and qualitative content analysis results for the public's perception of nanotechnology food product labeling. Chapter V discusses a couple of implications stemming from analysis results, and Chapter VI provides a summary of conclusions.

Chapter II: Previous Work and Research Questions

1. Public perception of nanotechnology

Numerous studies have analyzed public perception of nanotechnology both in general and considering specific factors and contexts. Overall, a large percentage of the public has little or no familiarity with nanotechnology and is unsure whether the risks outweigh the benefits of nanotechnology or vice versa (Satterfield *et al.*, 2009). However, a larger portion of the public views the benefits as greater than the risks compared to the converse case (*Ibid.*). Additionally, familiarity with nanotechnology appears to facilitate increased benefit perception while unfamiliarity does not seem to correlate with risk aversion (*Ibid.*). This indicates that assuming public awareness increases over time, benefit perceptions may likely increase and remain dominant over risk perceptions. On the other hand, Kahan *et al*., 2009 argues greater nanotechnology familiarity polarizes views either positively or negatively, depending on individual cultural factors.

Looking beyond general perceptions, the following factors were demonstrated to significantly affect nanotechnology perception: framing effects, media exposure, trust in regulation/risk management, intuitive toxicology (how a lay audience reacts to quantitative toxicological information), attitudes toward environmental risks and science/technology, perceived naturalness, psychometric variables, cultural biases, affect as a heuristic, religiosity, income, and education (Satterfield *et al.*, 2009). Notably, political leanings, race, age, and gender were found to be both significant and insignificant factors in determining nanotechnology perception, depending on the survey viewed (*Ibid.*).

Given the broad array of perception factors studied and the steady growth of nanotechnology perception research, sorting and reclassifying the research results seems apt. Investigation of nanotechnology public perception is breaking into the domain of literature summary, review, and characterization to attempt to organize the array of individual studies and provide direction for future studies. Sattterfield *et al.,* 2009 has been the only meta-study, covering all nanotechnology public perception surveys up to 2008. Currall 2009 aimed specifically at arguing for theoretical development beyond simple descriptive studies, citing work on the cultural-cognition thesis (Kahan *et al.,* 2009), religiosity and moral acceptance of nanotechnology (Scheufele *et al.,* 2008), and contextual factors such as institutions (Pidgeon *et al.,* 2009) as importantly advancing the breadth of theoretical considerations. From a more comprehensive standpoint, both Besley 2010 and Siegrist 2010 conducted reviews of previous nanotechnology public perception studies, each presenting similar issues, albeit discussing emerging themes differently. Besley 2010 provided a more descriptive summary of previous results in the areas of public knowledge, awareness, and factors affecting nanotechnology perception. In addition to citing mostly the same studies on these topics, Siegrist 2010 incorporated comparisons to biotechnology and matters affecting nanotechnology's sustainable development. Interestingly, each provided dissimilar suggestions for future perception research.

2. Nanotechnology in food and consumer behavior

Although public perception literature characterization is valuable, continuing to identify and resolve research gaps and areas demanding more attention is equally important. One key area is perception of consumer products containing nanomaterials, specifically nanotechnology food products. The nanotechnology food industry is likely to grow rapidly in the near future (Chau *et al.*, 2007; Chaudhry *et al.*, 2008); however, nanotechnology's advancement potentially hinges on the public's acceptance (Köhler and Som 2008; Macoubrie 2006; Royal Society and Royal Academy of Engineering 2004). As demonstrated by the varied acceptance of genetically modified organisms (GMOs) across countries, shifting public perception in response to news media, organizational/governmental outreach, or product-application availability and use may determine the success or failure of the technology. Notably, nanotechnology food public perception research is generally sparse (Cook and Fairweather 2007; Siegrist *et al.*, 2007), presenting a significant challenge for the effective and fair development of the nanotechnology food industry. Using food as the specific application in conversations with the public about nanotechnology applications is especially useful for eliciting public opinion. It is a tangible product that people interact with directly and daily, potentially facilitating clearer, better defined, and a greater variety of consumer judgment formations, compared to products without as much direct, frequent interaction (e.g., computer components).

Studies of public perception of food products containing nanomaterials or produced using novel technologies yield several insights thus far. In general, factors affecting consumer acceptance of food nanotechnology are dynamic, complex, interactive, and

interdependent (Yawson and Kuzma 2010). More specifically, Siegrist *et al.*, 2007 created a hypothetical model where consumers' social trust (in nanotechnology producers) impacted the affect regarding nanotechnology food information, which in turn fed into consumer benefit and risk perceptions, ultimately determining willingness-to-buy a given nanotechnology food product. Intuitively, social trust in producers had a positive willingness-to-buy impact, while perceived benefits had more of an effect than perceived risks (*Ibid.*). However, perceived risks of a processing technology were the most important variable in deciding interest in use of a food product processed with a novel technology (Cardello, Schutz, and Lesher 2007). Accordingly, consumers' conceptualization of nanotechnology in food may be more nuanced or differently developed than equivalent conceptualizations of novel technologies. On the other hand, consumers who demonstrated a willingness to consume foods processed by one novel technology had lower concern ratings for all technologies (Cardello 2003).

Looking at a wider array of influences, perceived benefits, perceived risks, perceived naturalness, and trust were important factors for determining public acceptance of innovative food technologies (Siegrist 2008), while similarly, the factors of food type, processing or production technology, costs, benefits, risk, endorsing agencies, and product information were significant components of consumers' willingness to use food products processed with novel technologies (Cardello, Schutz, and Lesher 2007).

Lastly, shifting attention to particular perceptions within food nanotechnology, Siegrist *et al.*, 2007 found the public is reluctant to accept nanotechnology in foods and packaging,

though nanotechnology in packaging was perceived as more beneficial than nanotechnology in foods. Furthermore, consumer willingness-to-buy was lower for hypothetical products with an added health benefit resulting from nanomaterial additives compared to natural additives, though higher compared to products with no additional benefit at all (Siegrist *et al.*, 2009). Consumers appear to desire health benefits even if it requires ambivalently perceived nanotechnology additives.

In summary, the strong role of perceived risks and benefits in conjunction with technology/product perception variation demonstrates thoughtful behavior among consumers to roughly estimate and weigh (differentially) risks and benefits in decision-making. However, consumer perceived risks and benefits of innovative food technologies and products may be unreliable as lay people may inaccurately assess such risks and benefits, placing more emphasis on consideration of consumer trust (Siegrist 2008).

3. Labeling of food products containing nanotechnology

An essential issue linked to nanomaterials in food, consumer perceptions, and willingness-to-pay is the labeling of food products containing nanomaterials. Notions of product labeling in general are inextricably tied to regulation, even in discussions about voluntary industry product labels. Nanotechnology product labeling is currently a contentious issue in America among select groups. Various organizations including Friends of the Earth, Greenpeace, and the Center for Environmental Health among others, formulated a citizen's petition in 2006, calling for the Food and Drug Administration

(FDA) to institute regulations on products it oversees that contain nanomaterials, including additional labeling on given products (Monica Jr. 2008). Other groups such as the Consumers Union and Environmental Working Group have maintained mandatory nanotechnology product labeling stances (*Ibid.*). In response to the petition and continued pressure from organizations to regulate and label nanotechnology specifically within products, the FDA reviewed arguments and solicited feedback from groups and experts through means of a Nanotechnology Task Force (*Ibid.*).

The FDA's July 2007 Task Force Report detailed their resulting stances and judgments. As it relates to labeling, the FDA held the position that mandatory product labeling should not be implemented as the current science had not indicated that product classes with nanomaterials were riskier than product classes without nanomaterials (*Ibid.*). Instead, the FDA called for evaluation on a "…case-by-case basis whether labeling must or may contain information on the use of nanoscale materials." (*Ibid.*). Moreover, the FDA sustained the idea that a warning label might not be useful if consumers do not understand nanotechnology's effect on a product (*Ibid.*). Since the 2007 report, the FDA has yet to put forth another substantial nanotechnology regulatory policy statement.

The FDA's stance stands in stark contrast to that of the European Union's (EU) approach. The Novel Foods Regulation is the key EU regulatory document in which food with nanomaterials is implicated. (Falkner *et al.*, 2009) Overall, the document covers food and food ingredients not consumed in the EU before May 1997, with the original goal to address GM foods; however, since it requires labeling of food and food ingredients

produced with a novel process, nanotechnology in food easily qualifies (*Ibid.*). Accordingly, the European Parliament and European Commission put forth suggested revisions in 2009 for the Novel Foods Regulation to include food with engineered nanomaterials as "novel foods" and to mandate labeling of nanomaterials in ingredient listings (*Ibid.*). As a consequence of this and other policies, strong divergence of nanotechnology regulatory policy and risk management between the US and EU is likely, leading to possible breakdowns or conflicts in international trade and regulatory agreement, among other problems (*Ibid.*).

Few studies have analyzed nanotechnology labeling issues, let alone addressed consumer perceptions and opinions of nanotechnology product labels. A premise not unique to nanotechnology products but well applicable is that labeling allows consumers to purchase products while managing risks (Stokes 2009; D'Silva and Bowman 2010). Concepts of mandatory labeling systems are often invoked, but given the FDA's resistance to mandatory nanotechnology product labeling, voluntary schemes are also discussed and being embraced in a limited fashion (*Ibid.*; Falkner *et al.*, 2009). Under a mandatory system consumers would benefit from improved information flow, ideally correcting consumers' knowledge deficiencies in order to make a rational product decision (Stokes 2009). Labeling, particularly under the present nanotechnology context, additionally brings in socio-ethical concepts of Consumer Rights, specifically, "The right to be informed" and "The right to choose" (Throne-Holst and Strandbakken 2009). Major drawbacks for mandatory labeling involve presumed high cost to industry for compliance and possible confusion, information overload, increased risk perception in

conjunction with decreased benefit perception, or misleading communication to consumers (Stokes 2009; D'Silva and Bowman 2010; Siegrist and Keller 2011). Instituting a voluntary system may be viewed as a low-cost and efficient alternative to a mandatory system (Stokes 2009; Marchant *et al.*, 2010), but uncertain industry compliance, inconsistency of message/labels, and potential divergence of practices between sectors and industries present significant challenges for an effective system intended to inform consumers (Stokes 2009; D'Silva and Bowman 2010; Defra 2008). Furthermore, in the case of organic labeling, the voluntary nature of the system has put the burden on industry and consumers to pay the additional costs incurred to support the system (Kuzma and Besley 2008). Shifting the responsibility and costs to industry and consumers is arguably unfair to such stakeholders, ethically (*Ibid.*).

As briefly referenced for mandatory labeling, but equally relevant to any labeling approach, accurate consumer understanding and label interpretation is vital. A label encourages consumers to engage in a cost-benefit analysis, though at the hazard of overestimating a product's risk of use (Stokes 2009), reiterating consumers' likely perceived risk inaccuracy problems posed by Siegrist 2008. Along similar lines, Siegrist and Keller 2011 found Swiss consumer risk perceptions increased while benefit perceptions decreased at the mere presence of a nanotechnology product label on sunscreen. Troubles also may arise if consumers cannot ascertain the specific health and environmental risks, it lowers safety expectations for a product, or it is unclear or complicated such that a consumer truly cannot make an informed decision (D'Silva and

Bowman 2009; Pape 2009). Consequently, labeling and consumer understanding issues are far from settled, and much remains to be investigated.

Lastly, one of the most crucial components of nanotechnology product labeling is public perception and opinion. Few studies address the topic and limited results exist, particularly because labeling matters are discussed secondarily or in combination with several other nanotechnology product issues. Based on a large citizens' jury in the U.K., NanoJury UK, and among numerous recommendations, one relevant to labeling emerged: "All manufactured nanoparticles should be labelled (*sic*) in plain English, classified and tested for safety as if they were a new substance." (Pidgeon and Rogers-Hayden 2007). Similar to NanoJury UK, a Swiss focus group event, nano-*publifocus*, addressed several nanotechnology aspects, with a key sentiment emerging that products with synthetic nanoparticles should be specifically labeled to inform users of what chemicals/compounds were present in order to make an informed choice (Burri and Bellucci 2008). Participants in Norwegian focus groups also implicitly voiced preference for nanotechnology product labels when discussing general nanotechnology matters and under the context of specific products (non-food), implicating the "rights to be informed" and the "right to choose" (Throne-Holst and Strandbakken 2009). Notably, despite consistency of results thus far, all such studies were based in European countries, presenting representativeness challenges given varying perceptions among European and American populations. In summary, the dearth of nanotechnology product labeling research in the US presents an important void to be filled, particularly in the expanding area of food products.

4. Methodology selection and guiding questions

Studies eliciting public perception of nanotechnology in general and for specific applications and contexts have almost exclusively employed surveys. A few exceptions include Pidgeon *et al.*, 2009 (use of a deliberative technique), Pidgeon and Rogers-Hayden 2007 (citizens jury at NanoJury UK), Burri and Belucci 2008 (Swiss nano-*publifocus* focus groups), MacCoubrie 2004 (focus groups), and Throne-Holst and Strandbakken 2009 (incorporated focus groups among other processes). Although food product label topics arose variably in the aforementioned non-survey studies, no study has heretofore employed a non-survey technique with a specific component designed to exclusively elicit public perception of nanotechnology food product labels. Consequently, much of this information remains unexplored.

Focus groups are an effective non-survey technique for investigating public perception of nanotechnology food product labeling. While surveys are beneficial for inferential statistics and simplifying matters down to point estimates and intervals, they often overlook or completely ignore underlying processes or complexities participants use to select their choices. For the case of nanotechnology food product labeling, a survey can easily indicate frequencies of people who desire labeling. On the other hand, it cannot readily answer *why* individuals desire labeling or not, and even then, differentiate between various reasons of support or rejection. Focus groups facilitate detail-rich conversations and assist in unpacking the rationale behind preferences (Morgan 1996). In addition to providing a medium for an open-ended response, the nature of hearing others' thoughts creates the potential for ideas to be activated in participants that they

would not have had on their own, a so-called "group effect" (*Ibid.*; Morgan and Krueger 1993; Cary 1994; Cary and Smith 1994). As a result, the process behind making a decision, pieces of that process, and potential connections between concepts are more freely revealed.

Moreover, for less codified issues such as preferred labeling content or subjects for which little is known, a deliberative technique is far better suited than a closed-ended survey to produce and reflect the range and detailed thoughts of the public. In other words, it is difficult to design a closed-ended question for a topic whose best set of responses is unclear or impractically vast. Importantly, focus groups do not exclude the application of surveys and actually facilitate construction of helpful closed-ended questions. Even with limited groundwork established by an open-ended process like a focus group, closed-ended surveys may be designed around the range of views participants spoke to during the focus group (Morgan 1996). Therefore, focus groups are an important tool for not only creating a framework for exploring public perception of nanotechnology food product labels and the rationale behind them, but also for producing effective future surveys to home in on quantitative aspects.

Considering the previous research as a whole and the advantages afforded by focus group use, the following questions guide the following research, analysis, and discussion:
Q1: What are the major themes raised by participants regarding nanotechnology food product labeling?
Q2: What are consequent implications for future nanotechnology food labeling policy?

Chapter III: Methodology and Data

1. Focus group logistics and data sources

Seven focus groups, 90 minutes in length and ranging in size from seven to ten participants, were conducted between September 2010 and January 2011 in the Minnesota cities of Minneapolis, Richfield, and Bloomington, and the North Carolina cities of Raleigh, Garner, and Carey. Cities were selected according to the main city location, the largest suburb, and a randomly selected city containing between 30,000 and 60,000 residents, all within the counties of Hennepin, Minnesota and Wake, North Carolina.

Participants were recruited using a stratified random sample, with the goal of having equal female and male numbers in each group, while matching a demographic county profile. Those who had a prior background in or extensive knowledge of nanotechnology were excluded from participation. The profiles were based on age, sex, race, education, family household income, and ideology (liberal, moderate, conservative) criteria, and generated by means of census data in conjunction with information supplied from select city community centers. Telephone and cell phone samples for each city were acquired and used to recruit 12 participants for each focus group, with the expectation of 75% attendance per group. Participants were given light dinner refreshments and $100 cash for their participation.

A total of 56 participants partook in one of the seven focus groups (n_1=8, n_2=10, n_3=8, n_4=7, n_5=8, n_6=7, n_7=8). The overall demographic distribution contained more males

(64%, n=36) versus females (36%, n=20); whites/Caucasians (84%, n=47) versus blacks/African Americans (11%, n=6) and Asians/Pacific Islanders (4%, n=2); and those with a post-graduate or professional degree (27%, n=15) versus college graduate (23%, n=13), some college (16%, n=9), high school graduate (14%, n=8), technical college graduate (7%, n=4), some high school (5%, n=3), some technical college (2%, n=1), and "Other" education (2%, n=1). Race/ethnicity and education had n=1 and n=2 "No Answer" responses, respectively. The most common age bracket was 50 to 60 (36%, n=20) compared to "Over 60" (23%, n=13), 41 to 49 (23%, n=13), 31 to 39 (7%, n=4), and "Under 30" (7%, n=4). Additionally, two provided "No Answer" for their ages.

Focus groups were executed by a moderator and note-taker, in addition to all groups being audio recorded. Transcripts for data analysis were constructed from the audio recordings, guided by note-taker notes. Data sources for each group consisted of focus group transcripts, in-group work sheet responses, and responses to a post-survey. Each group followed the same moderator-initiated topic and question flow, which occurred as follows: participants' first thoughts about nanotechnology, moderator's reading of a prepared general background statement about nanotechnology, resulting participant perceptions and reactions, moderator's reading of a prepared statement about nanotechnology in food applications, resulting participant perceptions and reactions, individualized completion of in-group worksheets, discussion about worksheet responses, discussion about nanotechnology food product labeling, and final participant thoughts.

Worksheets listed the broad nanotechnology food application areas, “Food additive”, “Packaging”, and “Processing”, each of was combined with the four possible intended functions of “Enhance Experience”, “Enhance Nutrition”, “Prevent/Reduce Spoilage”, and “Cheaper Production”. Space was provided for participants to list their perceived benefits and concerns, in addition to selecting their willingness-to-use per application and function, on a 1-to-5 scale. Post-surveys were emailed to participants after focus group completion and asked questions regarding issues related to nanotechnology in general and in food, including willingness-to-use, labeling, and regulatory matters. See Appendix A for the full focus group discussion guide, prepared background statements, in-group worksheet, and post-survey.

2. Analysis methods

Transcripts were analyzed using NVivo content analysis software by means of assigning codes (i.e., labels) to participants’ statements. A multi-level descriptive coding method was applied with most statements being assigned one or more codes. Off-hand comments unrelated to the discussion and similar remarks were not coded. Codes mostly fell into one of the three following categories: topic, intent, or a combination of both. Topic codes reference a specific subject raised by the participant, while intent codes were additionally assigned when some sort of preference or recommendation was supplied. Since most statements involved preference or views regarding one or more topics, the majority of codes represented a topic-intent combination. In order to capture the range of issues, scope, and complexity in numerous comments, several codes were frequently assigned to account for concrete or specific issues raised and larger themes participants may

knowingly or unknowingly have implied (e.g., concerns regarding nanotechnology's use in children's products speaks to the concrete issue of children's products in addition to the broader themes of risk and inter-generational differences).

Since each group followed the same question flow, corresponding transcripts were easily divided into six phases: (1) unprimed nanotechnology perceptions, (2) general nanotechnology perceptions, (3) nanotechnology in food products perceptions, (4) worksheet and consequent discussion, (5) nanotechnology food product labeling, and (6) final thoughts. Phase demarcations were determined based on the moderator's explicit transition questions or statements, which clearly specified what topic was to be discussed by the group. Each phase elicited enough topic variety with respect to every other phase that separate coding lists were generated for each phase and applied across all groups. As a result, each phase contains a notable number of codes unique to that phase; however, many themes arose repeatedly across phases, thus several codes appear in multiple code lists.

Upon full transcript coding completion, each code had an associated count per phase. Counts were simply the number of times the code was applied to a given portion of text. Counts were assigned accordingly to what constituted a complete expression of a theme or multi-participant exchange regarding a theme. Sometimes a single participant statement addressed one or more ideas, from which no other participants initiated follow-up. When no debate or additional commentary occurred, the single statement constituted a single count. In many cases, on the other hand, multiple participants and the moderator

debated or spoke to an idea, implicating several statements. The set of related statements in an exchange thus comprised the count.

Although all phases in each focus group were coded, analysis for this paper focuses exclusively on the fifth phase, nanotechnology food product labeling. Upon coding completion, codes with at least 10 counts in phase five were isolated as key labeling themes. The resulting list of themes was refined to reduce redundancy and clarify meaning, and was dichotomized according to the relevancy to nanotechnology food product labeling. Themes unrelated to nanotechnology labeling were classified as "tangent" themes, while the rest were considered "direct" nanotechnology product labeling themes. Tangent themes were defined, given a representative statement or exchange, and listed in descending order of count frequency, as shown in Table 4.1. Direct themes more easily fell into a hierarchical structure, resulting in the creation of four main themes, three of which contain multiple sub-themes. Each sub-theme was defined and given a representative statement or exchange, as shown in Table 4.2. Additionally, Figures 4.6 and 4.7 present a select set of sub-themes and ideas arranged into a flow diagram to reflect logical connections synthesized by participants.

Lastly, quantitative worksheet responses and post-survey responses were tabulated, descriptively analyzed, and graphically presented using STATA. See sections 4.1 and 4.3 below for worksheet and post-survey results, respectively.

Chapter IV: Results

1. Quantitative worksheet results

In the fourth phase of each focus group, participants were given worksheets and asked to indicate their willingness-to-use for three different nanotechnology food products per four functions of the product on a one-to-five scale (see Appendix C for the complete worksheet). The three product category types are food additives, packaging, and processing, each of which is clarified on the sheet with a small graphic and descriptive preposition (i.e., "In" food, "On" food, and "For" food, respectively). The four functions assigned to each product category are "Enhance Experience (e.g., flavor/color)", "Enhance Nutrition", "Prevent/Reduce Spoilage", and "Cheaper Production". Thus, each participant supplied up to 12 willingness-to-use responses. Worksheet results are shown in Figures 4.1 through 4.5. In summary, participants are most willing to use nanotechnology in the application of food packaging, especially for the beneficial functions of enhancing nutrition, reducing spoilage, and leading to cheaper production. In contrast, participants are least willing to use nanotechnology to enhance experience, particularly across food additive and processing applications. It is also worth noting that standard deviations of averages are large for all measures, which is to be expected for discrete data occupying integer values across a small minimum to maximum value range.

Figure 4.1 presents the full results for participants' average willingness-to-use certain nanotechnology food applications according to the specific benefit provided. Most averages hovered around the neutral response, "neither willing nor unwilling to use", ranging from 2.6 to 3.9. Nanotechnology in food additives and for food processing for

the purpose of enhancing experience were rated the lowest, between "fairly unwilling to use" and the neutral response (2.6). The top three averages fell between neutral and "fairly willing to use" and all were in the packaging category for the purposes of enhancing nutrition (3.7), reducing spoilage (3.9), and reducing production costs (3.5).

Application and function preference differences are detailed in Figures 4.2 and 4.3, respectively. Regarding applications, participants were clearly more willing to use nanotechnology food applications involving packaging (3.5) than either food additives (3.0) or processing (3.0). The stronger willingness to use a packaging application relative to other nanotechnology applications aligns with previous results demonstrating the public's higher benefit perception of nanotechnology in food packaging compared to in food itself (Siegrist *et al.*, 2007). Considering willingness-to-use of each function independent of application reveals "Enhance Experience" to be the lowest rated and the only function whose average is below the neutral response (2.7). The remaining functions of "Enhance Nutrition", "Prevent/Reduce Spoilage", and "Cheaper Production" contain similar averages all between the neutral response and "Fairly willing to use": 3.5, 3.4, and 3.2, respectively.

Frequency distributions of aggregate willingness-to-use responses for applications and functions are presented in Figures 4.4 and 4.5. As reflected in the higher willingness-to-use average, packaging has the most left-skewed distribution, whereas food additive and processing distributions are similarly less skewed with notably higher counts of "Strongly" and "Fairly" unwilling-to-use. Regarding function frequency distributions,

above-neutral willingness-to-use averages are seen by the slight left-skewed distributions in all functions except "Enhanced Experience". Interestingly, "Enhanced Nutrition", "Reduced Spoilage", and "Cheaper Production" show fairly equivalent distributions, though "Enhanced Nutrition" most clearly contains the smallest number of below-neutral responses compared to all other functions.

Figure 4.1 – Average willingness-to-use of a nanotechnology food application for different benefits/functions of the given application. "F.A." = Food Additive, "Pack." = Packaging, and "Proc." = Processing.

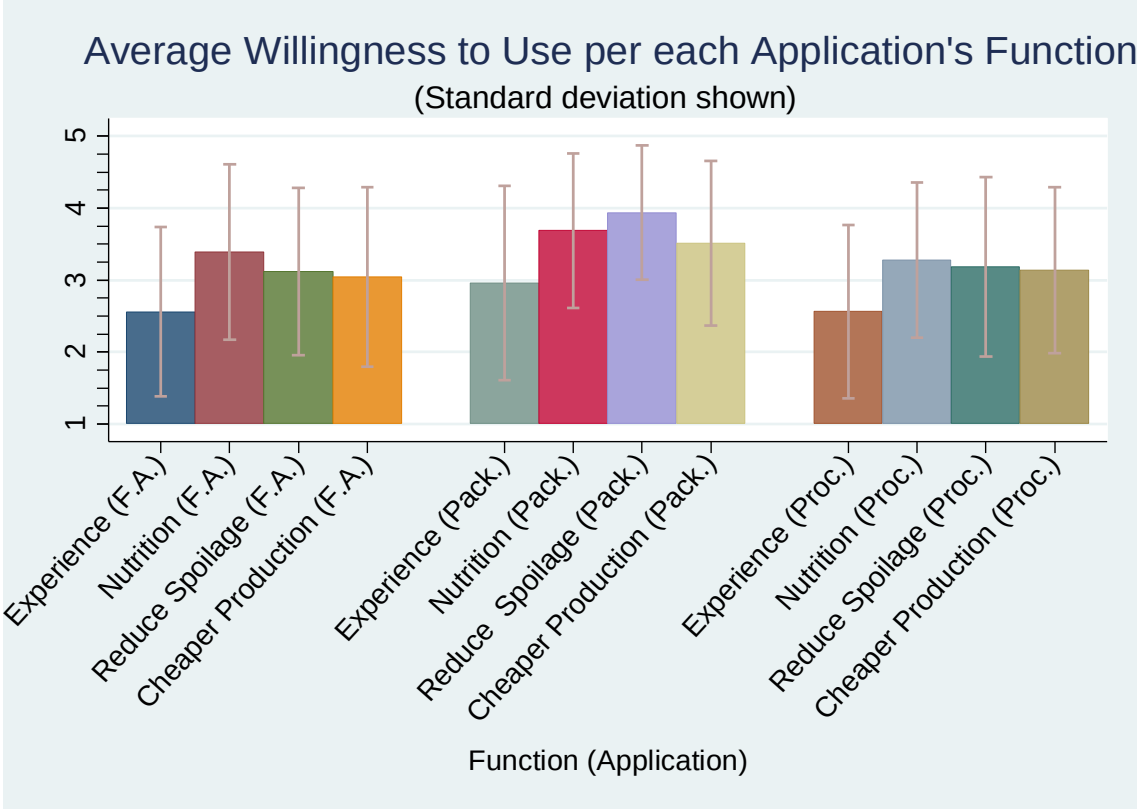


Figure 4.2 – Average willingness-to-use of nanotechnology food applications with data aggregated across functions.

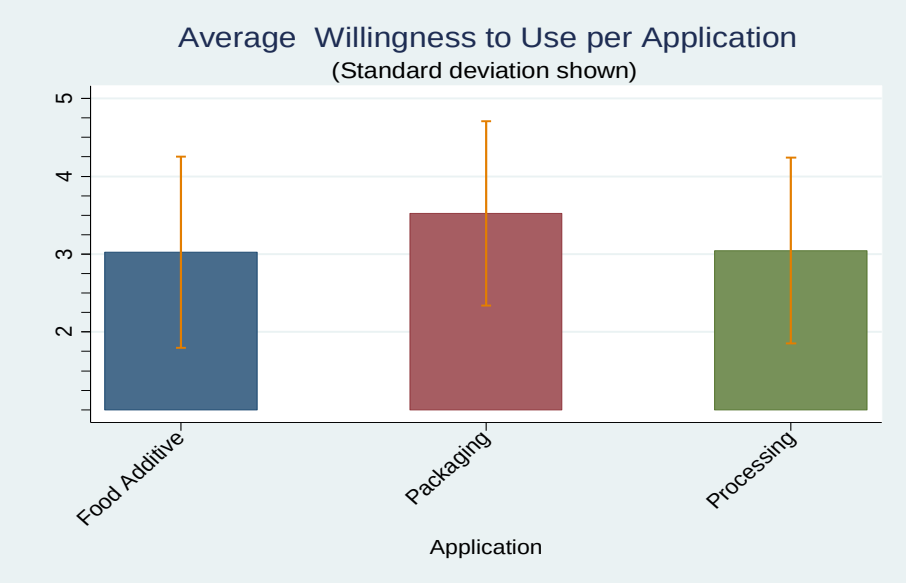


Figure 4.3 – Average willingness-to-use of nanotechnology food applications according to benefit/function with data aggregated across applications.

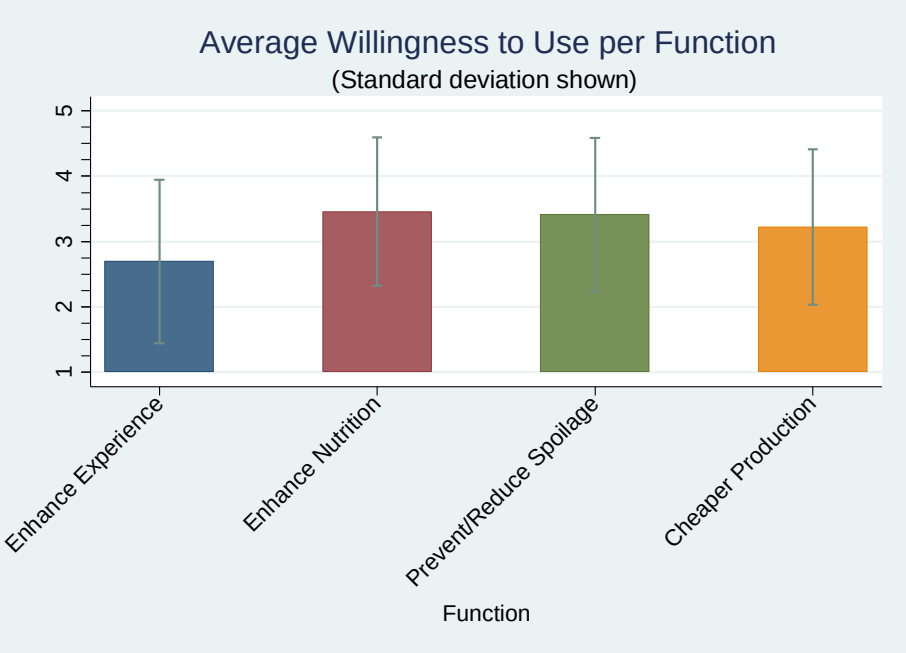


Figure 4.4 – Cumulative willingness-to-use response distributions per application

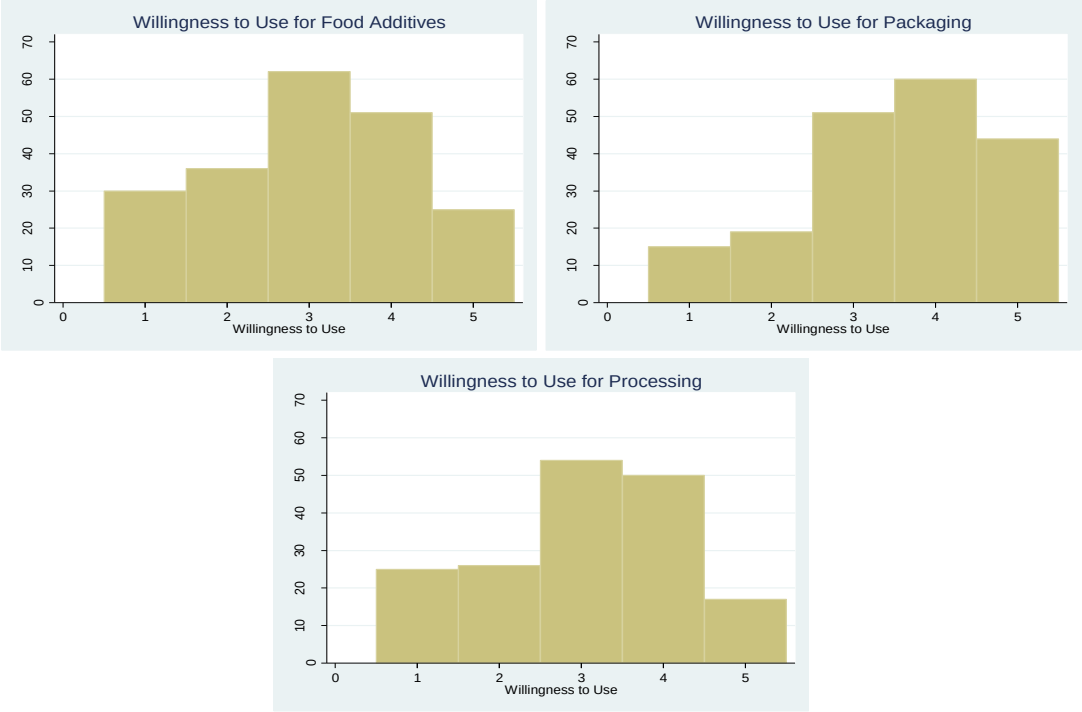
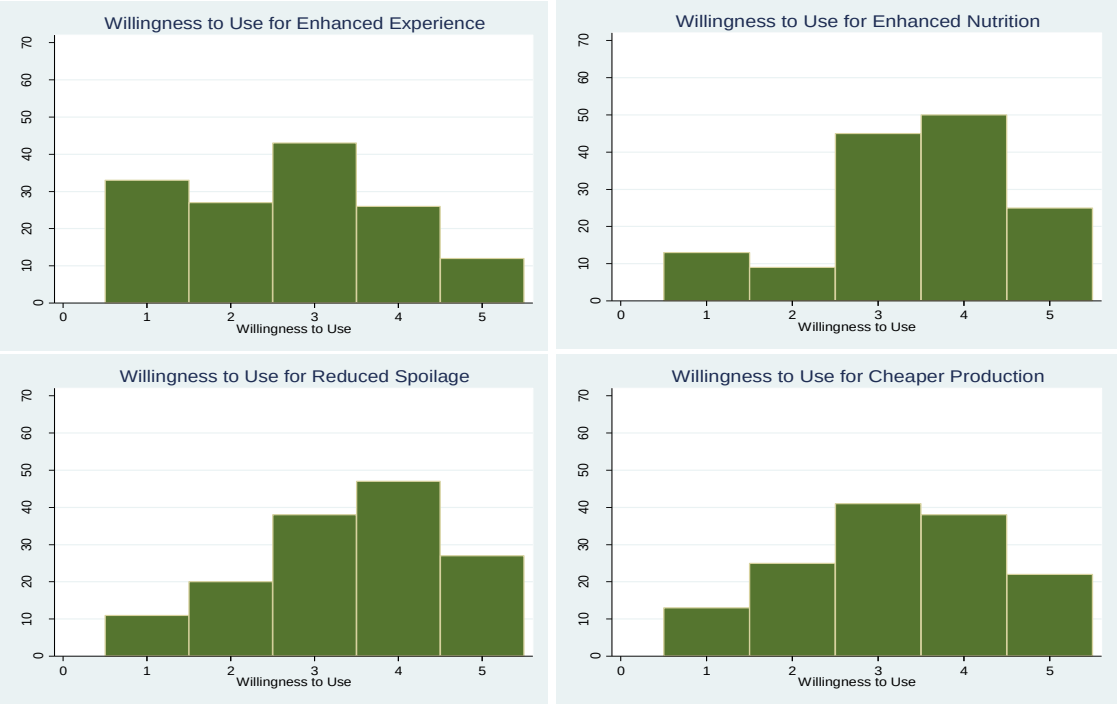


Figure 4.5 – Cumulative willingness-to-use response distributions per function



2. Select qualitative focus group results from phase five (labeling phase)

Creation of final codes for the following results tables consisted of a two-part process. First, a large number of coding themes were generated based on typical terms arising in the emerging technology public perception literature, such as “Trust”, “Risk”, “Benefits”, etc. Second, numerous new coding themes were created inductively upon reading through focus group transcripts, due to the large volume of topics and issues arising per group worth capturing. Accordingly, inductive themes were assigned simultaneously with literature-generated themes. See section 3.2 for a full description of how themes were selected and organized for these results, based on frequency and content.

i. Themes tangent to nanotechnology product labeling

Table 4.1 lists most frequently mentioned themes and topics raised in the labeling phase unrelated or indirectly related to nanotechnology product labeling. A sample quote or exchange is provided for each theme in the table and each is defined and discussed below. It is worth mentioning that within many themes the comments and exchanges are quite disparate in nature, creating difficulty for intra-theme comment comparison.

“Reference to Existing Products” captures any comment where a brand name, consumer product, or drug/medication was mentioned. Cigarettes and drug warnings were mentioned often and in the context of label effectiveness, especially if the label served as a warning mechanism. Other comments covered a wide range of matters such as prescription drugs, genetically modified corn, and NutraSweet.

"Risks" constitutes a broad categorization, covering any statement about explicit or implicit risk or harm or how it is communicated. Unknown risks of various products, safety testing in general, and individuals' understanding of such matters were commonly raised, as captured in comments such as, "*Well we don't really know about GMO. How is that going to affect us long term? Ok, I'm almost 50, I've got some concerns, but if I had a three year old child I am going to be more concerned*", and "*Grew up with microwaves, Microwaves, even when it first came out, you use the microwave you will get cancer, still there.*"

"Willingness-to-use" covered any statements indicating a person's willingness to use a product and/or factors influencing individuals' purchasing behavior. Explicit willingness-to-use was sometimes indicated with a statement such as, "*Two products, one has 40 ingredients and one has 3, I am probably going to buy the one with 3 because I don't know what all this other junk is, usually additives to make it seem like it is something that it really isn't.*" On the other hand, willingness-to-use issues were merely implied by several comments. For example, in response to being questioned by the moderator about purchasing or not a labeled nanotechnology food product, one respondent answered, "*I'd let my neighbor eat it first.*"

Numerous comments either directly or indirectly indicated a participant was unconvinced of the truth, outcome, or optimism surrounding a given topic. These were grouped under the hood of "Skepticism", covering ideas such as uncertainty of product benefits and subversion of labeling efforts by company marketing. Related to the former point, one

participant provided a counter perspective to nanotechnology product buzz, stating, "*I don't know if something like this came up…I don't know that naturally everyone would gravitate towards it, I mean naturally there would some that are not all that concerned anyways, and they go 'oh this tastes better', but people in general, there is a hesitancy when you come out with something like that.*"

Discussion of nanotechnology labels inspired conversations about the labeling of other specific products and more general labeling issues such as allergy warnings on food products. These all were considered under "Other Product Labels". Drug warnings and labels were frequently highlighted.

The topic of "Trust" emerged from participants' statements in many forms, including consideration of (dis)trust toward scientists, companies, and regulators, among others, but only a few statements per sub-topic arose and were effectively covered by other codes such as "Skepticism" and "Concern for public's interest" (see below). Highlighting two institutions/groups, in short, concerns existed about profit-driven motives for companies and mixed trust existed for regulation and the FDA. Two participants voiced active distrust or doubt for the FDA, and three indicated or implied trust in the FDA. The former idea is shown here, "*You can't trust the government or the FDA, look at the drug recalls, there are a lot of bureaucrats, they don't know what they are doing either, I am sure it is a long way to go.*"

Discussion about safety and risk of products were typically framed in terms of product safety testing and regulation, thus necessitating a "Testing" code. Testing was also raised in the context of product development and how much testing is sufficient for safety, which can be seen one of two quotes for "Testing" in Table 4.1 and this statement, "*But where do you draw the line? [With] the number of years of research already, where do you draw the line? There has to be sometime when you say, 'ok now we have to go to production'.*"

"Concern for public's interest" is connected to a unique combination of "Trust", "Skepticism", and/or "Risks". Statements coded as such questioned whether or not the public's welfare and opinions were being considered by companies and governments. This participant put forth the sentiment, "*I don't think any technology is brought in, in our best interest except for money. Money brings in technology, they can sell it to you and make money on it, they will research it trust me.*" Similar and somewhat overlapping with "Reference to existing products", the theme of "Past information" specifically captures references to situations, products, or regulation spoken of in the past tense or as a trend or perception no longer applied at present. Clear examples were those where public knowledge about a product's characteristics change (e.g., healthfulness of trans-fats).

Comments coded as "Benefits" were present much more strongly in other phases of the focus group, but appeared in the labeling phase for three groups, nonetheless, though disconnectedly. Three participants indicated a willingness-to-pay or willingness-to-use

increase for a realized benefit from nanotechnology in a product, as stated here, "*Well if there was a bottle of nanotechnology aspirin and a bottle of regular aspirin and I know that the nanotechnology aspirin was going to work faster and better, I would buy the nanotechnology aspirin.*" One individual repeated the benefits presented in the informational document about nanotechnology in food as justification, "*Last longer, store longer, less spoilage, more money, it wouldn't be a big deal, but it would have to be a benefit I think or enhance it. I think everyone is willing to pay a little more to make it better*." Notably, two "Benefits" statements were voiced in the context of skepticism about industry (see the first sample quote in Table 4.1, under the "Benefits" code), "*It is like advertising. The best advertising sells the most products. If she can tell me ten reasons [why] I should buy nano food and he can only tell me two reasons [why] I shouldn't, I am probably going to buy nano food. I mean it's most things in this world, I don't care if it is food or what it is, revolves around dollars. People will bring new technology, that is what they see at the end of the road. They are not trying to make me be 200, they are trying to fatten somebody's wallet and fill the big corporation [with] whatever that takes, and they are willing to do a try. This nanotechnology wasn't free to develop, that is pretty obvious, somebody is going to pay for it, and so they are looking for ways to sell it to us. But with all our knowledge, nobody has billboards up that say get your food at Cub because we have nanotechnology. They are just sliding it in on us.*" The benefit sub-theme underlying this comment presents the perception that benefits to the public are not the driver of nanotechnology product development.

Lastly, statements referencing “Nutrition and health” were more prevalent in other phases of the focus groups, but appeared somewhat in the labeling phase under multiple contexts including food healthfulness and interpretation of nutritional information on labels.

Table 4.1 – Themes tangent to nanotechnology product labeling arising during phase five. Note: "counts" refers to the number of statements or exchanges coded for the given theme. Almost all statements were coded under multiple themes, i.e., "cross-coded". However, such cross-codes are highlighted for other themes only present in this table.

Theme (counts)	Example Statements
Reference to existing products (57)	2.3: Well you know you look at this [holds up diet coke], this has a warning on it, cigarettes have a warning in it, and yet people still drink it. It tells you what it is but if you don't know what this warning means, ya know? You don't know. 1.5: Although, I will give kudos to formulas, obviously a good thing, I have a ten month old kid myself, so we breast fed for the first couple months and then it has been formula ever since and I don't think they grow formula on trees and I don't think that comes out of cows but, somehow they genetically engineered it, and it's pretty darn good for my kid, so, he keeps gaining weight so, I suppose there is some positives behind it.
Risks (40)	2.3: Well we don't really know about GMO. How is that going to affect us long term? Ok, I'm almost 50, I've got some concerns, but if I had a three year old child I am going to be more concerned. What is the long term because GMO products haven't been around that long in my lifetime but it is a potential everyday occurrence for a three year old growing up. It's like you said, you talked about the lead soldering, you know, I wasn't exposed to that but my dad was **[Cross-coded under "Reference to existing products", "Past information", and "Trust"]** 3.7: At least I would say is that harmful to you it is not a … you need to know how nanotechnology affects your body, is it going to block your arteries, maybe one molecule will kill you, you don't know..
Willingness-to-use (36)	3.1: Well you know we've got additives in everything we eat almost, unless it came out of the garden or you made it, and um you make choices like that all the time, but most of the time it comes down to the marketing that you have been marketed to and you say oh yeah that really looks good, I am going to try that, and then if you like it you keep on trying it and all of a sudden, no, let me read that package again, no I like it I will keep doing it, that's what it comes down to a lot. 5.6: I think it is a huge learning curve for the average person who would be comfortable saying I want to go buy this because it has nanotechnology in it. Most people would see nanotechnology, there are lots of 20 syllable ingredients we can't pronounce and we don't know what they are anyways. People are going to buy it, if it is not a wholesome food anyway, buyer beware.
Skepticism (26)	4.3: If my lettuce rots tell them to call my lawyers see if I can get my money back. I'm just skeptical until I've been shown it's a benefit or not a benefit to me. I don't understand nanotechnology myself so I am skeptical of it, especially if it's going to cost me more money for something I can't prove to myself cause I may end up dead from it. It's like life insurance; it ain't much good for the guy who bought it for himself. **[Cross-coded under "Benefits", "Reference to existing products", and "Risks"]** 3.4: I mean if you were to go to the grocery store today and you were to see nano enhanced cheese, would you buy it? Probably not. Moderator(3): Would you? 3.6: No, I don't know if something like this came up, a product come out I don't know that naturally everyone would gravitate towards it, I mean naturally there

	would some that are not all that concerned anyways, and they go oh this tastes better trial, but in general people, there is a hesitancy when you come out with something like that. I think a lot of people have the common sense. **[Cross-coded under "Benefits" and "Willingness-to-use"]** 6.7: It would really have to convince me it was worth paying more. Just because it says nanotechnology doesn't mean it's better. It would have to be something with my own research that convinces me. **[Cross-coded under "Trust"]**
Other product labels (23)	3.6: I think the oversight is pretty extensive on the food industry and you know they have the label when it is in the same plant as peanuts and other nuts even if it doesn't contain any of those things and so I think it is going to be on a label, anything new like that is going to be on all labels, it is going to be required. **[Cross-coded under "Trust"]** 1.2: Labels are used now on just about everything and any kind of additive you've ever heard of and most that you haven't, trees and nuts with it on it, manufacturing
Trust (19)	2.3: Well I think if you have a drug specific to you, so you are probably getting a doctor to prescribe it and I would expect my doctor to know, why do I want this drug over this drug, and I expect my doctor to explain to me, here is choice, which one do you want to use and I would ask his expertise opinion because in that respect I don't have that necessarily , I can do research myself but if I need something right away I'm going to ask the expert. **[Cross-coded under "Reference to existing products" and "Willingness-to-use"]** 7.5: You said already with labels on cigarettes cause these problems. I mean at least inform the public and let them make the decision themselves. Like he said if it looks good I am going to buy it, I don't care for it, I trust people the FDA, the people producing it to make sure it is edible and nutritional or whatever. **[Cross-coded under "Reference to existing products"]**
Testing (16)	7.5: Yeah but if you say I am going to do 5 years research, I'm going to do 10 years, I'm going to do 15, then you're 15 years off from making any money and your company doesn't produce. You have to draw the line, I did five years of this and simulated this for 15 years, let's go to production. 5.7: There is always going to be a group of scientists somewhere that is going to dissect what you put in foods. Anything that comes out, especially any new technologies is going to have scientists, going to have some group that says, we tested this and it is going to fail your kidneys. There is always a group that is going to dissect when a new product comes along. **[Cross-coded under "Risks"]**
Concern for public's interest (15)	1.7: Well I think it might be a mindset too. Are they really out to hurt me? Or are they really out to give me more nutrition? 1.1: I agree, I would think more along the lines that they are trying to do something good. 1.7: Yeah, agrees 1.1: They're not trying to… 1.8: Do us all in 1.1: Well, or, take over our minds with some kind of control **[Cross-coded under "Risks" and "Trust"]** 4.3: I don't think any technology is brought in, in our best interest except for money, money brings in technology, they can sell it to you and make money on it, they will research it trust me. **[Cross-coded under "Skepticism" and "Trust"]**

Past information (15)	4.1: Remember eggs were no good for you; bacon was no good for you 4.5: Even vodka is good for you. Group: (Laughs) 4.3: Eat fish, but don't eat it if it came out of that river or this lake or… **[Cross-coded under "Reference to existing products"]** 3.4: Take this stuff, it used to have NutraSweet in it, everybody drank it and then they get the long term effects on it and then all of a sudden I can't even pronounce this word, it contains this product so it's there you know. 3.1: Psycho mated soft drinks in Canada. 3.6: Globally where is this going to go. 3.1: But then you got studies that say that study was no good. What studies do you believe? **[Cross-coded under "Reference to existing products", "Risks", "Skepticism", "Testing", and "Trust"]**
Benefits (14)	3.6: No, I don't know if something like this came up, a product come out I don't know that naturally everyone would gravitate towards it, I mean naturally there would some that are not all that concerned anyways, and they go oh this tastes better trial, but in general people, there is a hesitancy when you come out with something like that. I think a lot of people have the common sense. **[Cross-coded under "Skepticism" and "Willingness-to-use"]** 4.3: So like if my lettuce lasts for three weeks in Canada with no refrigerator I will pay a nickel more for the bag. 4.7: That is new and improved. **[Cross-coded under "Reference to existing products"]**
Nutrition and health (10)	5.8: I have been trying to do a better job. I go to the gym for the last year and a half or so and I am trying to focus more on the healthy fats, proteins, and good carbs, just try to focus on those a little better stuff. When I was a freshman in college I just ate whatever was in front of me. Moderator(5): So you still don't read the labels though right. 5.8: Um, I have started to look at labels for the specific items but I don't read the whole ingredients. 4.7: Trans-fat, when that came out that was big, it was big on everything, now it is on the back 4.1: Now it is big that it says zero trans-fat 4.7: It was such a big deal, but I think when this comes out people are going to be curious about it and you know try some things and see if there is a difference but I think it depends on how it's given to the public and how it's delivered. **[Cross-coded under "Reference to existing products", "Other product labels", and "Risks"]**

ii. Nanotechnology product labeling themes

Table 4.2 presents a hierarchically arranged set of themes with an example statement or exchange raised during the labeling phase that dealt directly with nanotechnology product labeling. Since numerous coded themes logically connected and overlapped with one another, a two-tiered hierarchy was developed in order to intuitively group related themes. The major themes resulting from the regrouping are "Label Preferences", "Label Use Moderators", and "Information Sources", each of which contains respective sub-themes. Additionally, as in the case for themes tangential to labeling, "Skepticism" was included as a stand-alone theme, since several statements regarding nanotechnology labeling invoked such a sentiment. Each theme and sub-theme is discussed as follows.

"Desire for a label", "Usage and purpose", and "Characteristics" comprise the main theme, "Label Preferences". This covers statements regarding the content and views about the nanotechnology product label itself. "Desire for a label" is a straightforward code, signifying valence toward a label's presence. Most participants who spoke on the matter voiced a desire for a nanotechnology product label. Only one participant out of 56 vocalized opposition to a label in this phase, while a few were unsure. See Table 4.3 for a breakdown of "Label Preferences" responses. Comments speaking to how someone uses a label, thinks a label is used, or for what purpose the label exists were counted under "Usage and purpose". Several kinds of functions were suggested, including treatment of the label as an informational device. Lastly, "Characteristics" address participants' sharing of concrete suggestions for a label's content or its location on a

given product. The most commonly recommended characteristic was to display the label on a package's front side. See subsection 4.2.4 for more exploration of these results.

The second major theme, "Label Use Moderators", is composed of "Effectiveness and consumer behavior", "Regulation perception", and "Consumer choice perception". These sub-themes help describe factors spoken by participants that are extrinsic to the label itself but still affect the label's use. "Effectiveness and consumer behavior" covers statements of concern pertaining to the usefulness and impact of a nanotechnology product label in terms of purchasing decisions. A significant view in this sub-theme was how a public lack of knowledge about nanotechnology or information on labels contributes to a label's ineffectiveness. The perceived ineffectiveness impacted how participants hypothetically considered the purchasing of a labeled nanotechnology product, as suggested by this individual, "… *but putting that (label) 'made with nanotechnology' isn't going to mean anything to anyone, unless they know (what nanotechnology is).*" Six exchanges were sorted into the "Regulation perception" sub-theme, which directly integrated opinions about regulation into a nanotechnology labeling context or indirectly held implications for such a context. Two key disparate views emerged, both from two participants in the same group. One participant voiced confidence in the FDA eventually requiring a label, "*I think the oversight is pretty extensive on the food industry and you know they have the label when it is in the same plant as peanuts and other nuts even if it doesn't contain any of those things and so I think it is going to be on a label, anything new like that is going to be on all labels, it is going to be required.*", while another voiced much skepticism about the FDA's actions

(see example quote in Table 4.2 for "Skepticism"). Related to "Desire for a label", the "Consumer choice perception" sub-theme involved statements from vocal proponents of label implementation. Consumer choice and the "right to be informed" were typically invoked in these exchanges as reasons for desiring the label. The label therefore acted as an enabler of consumer choice from their perspective, as seen by these two participants, "*I think it's about giving people the information so they can make a choice, so the individual can make a choice.*", "*You make your choice. You want it you buy it. You read it, you don't want it, and you don't buy it.*"

"Information Sources" focuses on the issue of how the public should acquire their knowledge about nanotechnology in order to understand a label on a nanotechnology product. Relevant remarks were dichotomized as either "Institutionally-based" or "Personally-based", each with seven comment/exchange counts. "Institutionally-based" comments incorporated the judgment that governments or businesses should be or have been the source of public information and education. Such statements were generally tied to other issues like trust, as in this comment, "*I just hope that the industry would try to do an appropriate job and say 'hey this is in here' or 'it is made with this kind of processing plant'. If you are forthcoming then you don't have to tell as many lies later.*" Responsibility to learn was hence shifted away from the individual in these instances. Comments coded as "Personally-based" stand in contrast to institutional accountability. These participants thought or implied that the information search regarding nanotechnology in products or on a label should be the public's responsibility or that the opportunity existed for the public to take charge of their own learning. As in the case

with “Institutionally-based” comments, other issues were wrapped into the statement. For example, skepticism underlies this person’s words, “*It would really have to convince me it was worth paying more. Just because it says nanotechnology doesn’t mean it’s better. It would have to be something with my own research that convinces me.*”

Lastly, a few comments asserted suspicion or skepticism in a nanotechnology product labeling context and were accordingly assigned as “Skepticism” statements. A few participants doubted that labeling would be implemented or that consumers would have a voice in the decision-making process surrounding such implementation.

Table 4.2 – Nanotechnology product labeling themes and sub-themes arising during phase five. Note: "counts" refers to the number of statements or exchanges coded for the given theme.

Theme (total counts)	Sub-Themes (counts)	Example Statements
Label Preferences (67)	Desire for a label (26)	Moderator(5): … Do you feel like this is something that should be labeled as being nanotechnology involved? 5.4: Yes. 5.5: If there are potential harmful side effects. 5.4: Especially if there is ongoing research I think it should be labeled.
	Usage and purpose (11)	7.3: People should be informed too. Let's just say that there wasn't a label on there that this was nano or whatever and suddenly your children or you started feeling bad, you have no idea why, you are still drinking the same Pepsi you drank for the past 5 years but something has changed, it has a new nano can or whatever, you go to the doctor and nothing has changed so just inform people I think.
	Characteristics (30)	4.3: Yeah, we don't want it in the small print on the bottom. I mean in the beginning I wanted it on the front, I want them to tell me it is in there, ten years from now maybe they take it off or they put it in the small print, I don't care anymore.
Label Use Moderators (30)	Effectiveness and consumer behavior (15)	1.6: Well it depends how it is worded too. You know you can say anything on a package and people might not pay any attention to that. But how the wording is in it, will have a great deal on the affect it has on whether a person will view it negatively or positively. Happy little nano, ok fine! But bad nano? There is so much jargon that scientists use, or that advertiser's use that uh... what is the truth?
	Regulation perception (6)	5.7: I don't think it is going to be our concern anyways. I think it is going to be up to the FDA. So if they say it is ok then it is ok. You know, they say they want it on the package then that is how it is going to be, if they say it is fine and you don't need to put it on the package then that is what it will be. I don't think it will be up to consumers to have a decision on whether they put it on packages or not.

	Consumer choice perception (9)	4.6: Just like people are making the choice between natural, organic or not organic because now we kind of understand what that means. Even though labels are sort of not totally consistent but at least we understand the organic and now we can make the choice that we understand what it is. You just put nanotechnology in something without understanding it but if we begin to understand the difference we can make a choice. So if there was a difference and it came in both, people would want to understand the difference.
Information Sources (14)	Institution-based (7)	2.9: I think the public should be informed and make sure they're understood. You know what I mean, that should be enforced and understood so there is not any mixed feelings so there is not any people that don't understand it, you know what I mean, everybody's got the same booklet and the same pamphlet and it describes exactly to a T, so I mean there is no…
	Personally-based (7)	2.3: I mean with the government, I mean the food labels and things like that, you can get with the government I know they have free pamphlets you can get to the people. And the responsibility is on the individual to learn. You're either concerned, I know a lot of people will be incredibly concerned about it and some people think it is what it is, but it's still your responsibility, it is my responsibility to learn what I am eating. What is the information? If there is something that catches my attention I'm like... ok I want to do a little research. I'm going to go to that company's website, I expect to be explained to me in normal terms not legal terms, you know? Lawyer terms that no one can understand anything, but I think the real responsibility is on the individual.
Skepticism (6)		Moderator(3): Would you like to say a label on all of that? 3.2: I don't think they will. They don't do it right now, what is natural, that has been a point of contention for a long time, you can't say it's natural because it's got what percentage of it is natural and what percent of it is chemical or whatever nano, so I think you know, I see it coming down to a big corporation marketing and it is going to be overwhelming with all the benefits and none of the drawbacks, you know if we buy a can of coke and they did the advertisement the way they do the prescription drugs on TV you wouldn't even buy a can of coke anymore because of all those disclaimers they put on there you know, a lot of those are like saving things but they want to advertise so they throw all those disclaimers. If they did that on the products we wouldn't buy all the products because of all the disclaimers they put on it. Are they going to have all the disclaimers on it, I don't think so.

iii. Thematic flow for the public's effective use of a label

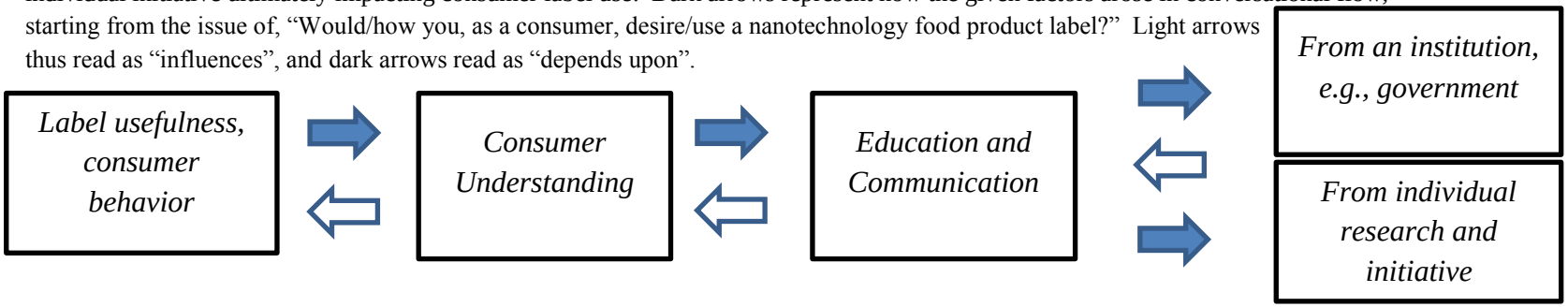
Figure 4.6 presents a logical arrangement of a key group of major nanotechnology labeling themes, as formed by participant statements such as the example quotes provided. Numerous comments addressed ideas well-connected to other comments speaking to nanotechnology product labeling. This occurred insofar as the content of one participant's statement was often related to another participant's statement in some meaningful way. One core set of connections between statements in the labeling phase dealt with the larger issue of how the public can effectively use a nanotechnology product label for a purchasing decision. Many comments tackled a slice of this issue, and therefore stringing together all relevant slices constructed a logical flow of concepts describing the process of creating the conditions to effectively use a label.

The components that emerged determining label effectiveness, which must be recognized in a defined sequence, are "Consumer Understanding", which is dependent upon "Education and Communication", which can be employed using an "Institutionally-based" approach or a "Personally-based" approach. The flow is intuitive, though a few points are worth mentioning. The emergence of a concern about "Consumer Understanding" stems from the wide array of comments invoking uncertainty about what nanotechnology is. In short, such comments took the form of "*How can I interpret a nanotechnology label if I don't know what nanotechnology is?*" Following the self-aware knowledge gap notion, the next rational step is to engage in education or communication of some kind. These comments took the form of an answer of sorts to the question posed above, in the general style of "*We first must understand what nanotechnology is.*"

Demanding to understand nanotechnology necessitates the final component: who does the educating/communicating. Participants who spoke to the matter presented two choices of either an institution such as the government, or simply the individual him/herself. No obvious preference or consensus was reached within any group concerning which of the two should be relied upon more heavily. Consequently, the value of this thematic flow results from not only providing a synergistic snapshot of participants' opinions, but also in identifying components of participants' rationales worthy of further investigation from a perception and preference standpoint. Such considerations are covered more thoroughly in Chapter V.

Fig. 4.6 - Thematic Flow for the Public's Effective Use of a Label

The ability for a consumer to sufficiently use a label in order to make a purchase decision emerged repeatedly across groups through several themes that naturally form a dependent chain. Light arrows show the order of influence, with education from institutions or individual initiative ultimately impacting consumer label use. Dark arrows represent how the given factors arose in conversational flow, starting from the issue of, "Would/how you, as a consumer, desire/use a nanotechnology food product label?" Light arrows thus read as "influences", and dark arrows read as "depends upon".



Illustrative statements:

Moderator(4): So let's just imagine for a minute they are labeling all those things. The products are labeled. Would that change your feelings about purchasing them?
4.1: It all depends on if we understand what this is going to do to us. I don't care if it is the government who is going to teach it to us, whatever. We have to know.

2.9: Well if there was a bottle of nanotechnology aspirin and a bottle of regular aspirin and I know that the nanotechnology aspirin was going to work faster and better I would buy the nanotechnology aspirin.
2.5: See I wouldn't. Because I just couldn't, maybe if it's been out there for awhile.
2.3: But maybe you would if you understood it.
2.5: Yes, if I understood it, I would
2.4: Education
2.5: I would educate, but the nanotechnology in food, I would go home and read about it

iv. Desire for labeling, perceived purpose, and the connection to preferred characteristics

Consideration of whether or not nanotechnology food products should be labeled elicited a range of responses, with "yes" being the most common. Only one participant answered "no", but did so in the context of desiring to avoid a false sense of protection labeling might provide if a given nanomaterial ingredient was unsafe. A few voiced mixed/tentative reactions or apathy. See Table 4.3 for a complete breakdown of responses. The major threads that ran through theses exchanges were how the level of perceived risk determined necessity of the label, or that certain individuals simply do not read labels, making labels meaningless to them.

Regardless of labeling preference, the connection of risk to most all responses was evident, implying how participants conceptualize nanotechnology's interaction with food and the purpose of a label. More specifically, extracting the motivations behind the labeling support reveals that those who cited a reason for desiring a label did so entirely in the context of desiring information to be allowed to make a choice. Although such consumer choice sentiments were unequivocally present, there often lacked additional explanation about consumer choice. In other words, consumer choice and desire for information often were implied justifications purely on their own merit, though the participant may have had a deeper reasoning in mind, such as with this statement, "*I think it's about giving people the information so they can make a choice, so the individual can make a choice.*" In contrast, one elaborate statement more clearly expanded upon consumer choice and highlighted that the choice at stake is one's risk exposure

autonomy: "*... the product that has nanotechnology, and it's a cracker, and everything is organic except for this part they used nanotechnology [for], so it is 2% nanotechnology,* ***now I can at least make an informed decision about how much risk I am taking***. *If they can find a way to say it's nanotechnology and it was for the processing of it and it was cheaper for us and we could ship it longer, and nothing to do with making it more nutritional then I am less likely to say 'well I'm a buyer I'm going to take a risk because it will increase your profit margin'. Not so much. So I don't know how they could label it in a way that is really informative but that would be helpful*".

Table 4.3 – Categorical breakdown of statements/exchanges for participants vocalizing labeling preference. Note: one statement and one exchange each presented two categories of labeling preference and were coded as such.

Response Category	Counts	Example Statement/Exchange
Yes	17	2.5: With food I don't care about everything, I'm the kind of shopper, I go to the store, I don't look at the calories, I don't look at the fat intake, I don't look at the sodium, I buy what I want to buy but if it has this nanotechnology I would want to know, I would want everything labeled.
No	1	7.6: Virtually I mean think of how many years that we, it is extremely common and beneficial practice that we use pesticides for food production. We did not label that these foods have pesticides on them. Now today we label them if they don't have pesticides on them but we didn't do that then and we can say what we want about pesticides but if we did not use pesticides in this country we should go around and decide which 1 out of 3 of us would starve to death and that is just a fact so we didn't label that. There was some talk about labeling food if it was genetically engineered but I don't remember seeing a label that says genetically engineered. Not in all the corn you were talking about not in the cows you were talking about, dairy cows are giving that additive that increases milk production so we are not doing that. I don't think labeling is a real, I wouldn't want the public to construe labeling as nanotechnology as protection because it's not. If there is something unsafe we need to identify it, prove it and stop using it. We don't need to label it and everybody use it anyway.
Mixed	3	4.6: Depends on the risk. Well if we find out more information and they say it causes cancer in rats, like smoking does, um, some of us are going to choose not to smoke because of that. It depends on the risk. Then I would want it large enough where I would notice it. The risk is well, it might just like everything else we eat, and I might not pay any attention to it.
Apathetic	6	4.3: I don't care about the labeling on the food. I want to know its safe, before the people making the food start using it. The government, I don't care who tells me, I want somebody who knows what nanotechnology is, is putting it in the food or whatever, I want them to publically say this is safe, will not harm you, we guarantee it.
Unsure	1	5.4: When it comes to the time when we know what it means it might be made prominent. It might be required to be made prominent and attractive for the producer. The producer might say this is going to be a big thing because of what the society now makes of it. But we are not there yet.

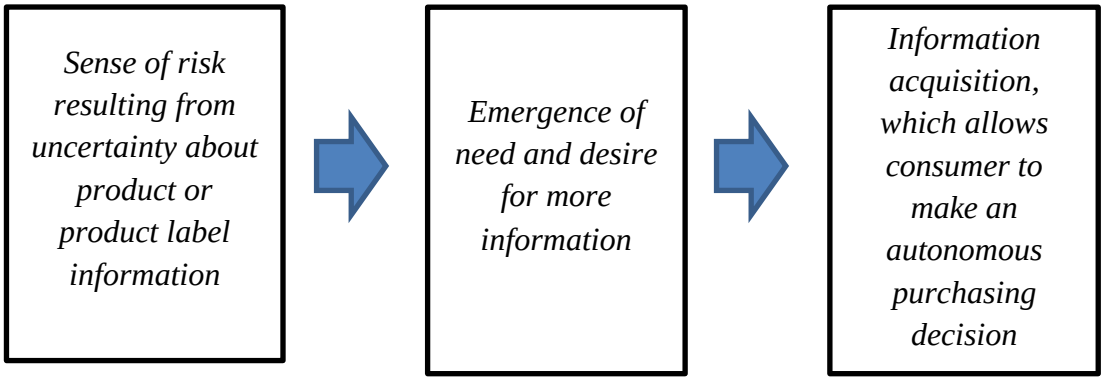
Risk was a strong theme throughout all focus groups (especially in the labeling discussion phase), and an important factor motivating consumer choice. However, when participants invoked consumer choice in a labeling context, they could have either had risk in mind or saw consumer choice's value on its own principle. Consequently, future research should address factors motivating consumer choice, both conscious to and implied by the consumer. Regardless, based on the discussion, one's belief of why a label should be present directly relates, if not overlaps, to his/her view of the label's purpose. Reframing "preference for a label" to "label purpose" appears beneficial for future conversations about labeling policy.

Less agreement existed for the specific purpose and function of a label compared to the general desire for a label. Although labeling support and consideration of consumer choice were not controversial stances, the nuances driving these concepts were evident in the variety of "label purpose" comments. The main purpose of a label as indicated by the focus groups is to inform the consumer. Being informed relates directly to statements about consumer choice, such as one previously highlighted, "*I think it's about giving people the information so they can make a choice, so the individual can make a choice*". The logical connection is that a label's purpose is to inform consumers so that they can make a product choice. Briefly, and alternatively, two people invoked the idea that a label simply scares consumers: "*I think labeling scares people… I think they're trying to improve, but that is why labels are scary because the way they're worded… All the long, long words.*", and from the same focus group and conversation, "*I would think so too, it scares me, and well it's all a circular saw.*" The idea of a fear response as it relates to

nanotechnology aligns well with Siegrist and Keller 2011, in which Swiss consumer risk perceptions increased while benefit perceptions decreased at the mere presence of a nanotechnology product label on sunscreen.

Putting the pieces of labeling preference and purpose together, the result is a picture of labeling in which risk and autonomy underlie most every relevant statement. Additionally, with the exception of comments citing to "Scare" as a label's purpose, all others linked to a sense of product risk, a need for information, or a need to make an autonomous choice. See Figure 4.7 below.

Figure 4.7 – Thematic Flow for Public's Sense of a Label's Purpose. The arrows are read as, "leads to".



An important connection to make is whether this sense of label purpose and risk sub-context reveals or explains the impetus for suggestions made about labeling characteristics. For our groups, labeling characteristics covered several areas but were mainly focused on communication and presentation issues. Interestingly, when

participants were prompted to comment on labeling characteristics, statements fell into one of two groups: how labeling *should* be vs. how labeling *will* be. Although moderator prompts were geared to elicit the former, the latter emerged often, possibly indicating among participants a sense of concession to whatever regulators or companies decide. As examples, one participant directly maintained the trusting position that the FDA will require nanotechnology to be on the label, while another skeptically asserted that companies will hide behind marketing and fail to reveal anything potentially negative on a label. Both views demonstrate what *will* happen in their minds in response to a prompt about what *should* happen. This can further be viewed as an example of the "Skepticism" theme present throughout the focus groups.

Regarding what a label communicates and what it should communicate, concerns and differing views existed. A few participants contended labels tend to use jargon or "long" words and evoked "scary" connotations. More generally, one person raised a simple yet profound point that not everything can be put on the label, while another had little idea how one could label something as "nanotechnology", given the broadness of the term. Related to nanotechnology's terminological breadth, two individuals shared starkly contrasting suggestions for what the label should say. One suggested the label remain "neutral", with the words "This product enhanced with nano-materials". On the other hand, another proposed listing the percentage of the food composed of nanomaterials, in addition to the purpose/benefit of the added nanomaterials. Lastly, two participants independently suggested the addition of a website or phone number if consumers sought more information about nanotechnology used for or in the food product.

Although a wide variety of ideas were presented, the dominant inclination was to provide as much information as possible in light of information overload or jargon. This connects to a label's risk communication purpose, as one not concerned about product risk may not be concerned about what a label says or the information quantity provided. This view is further supported when considering the remainder of nanotechnology labeling comments.

Considering comments speaking to a nanotechnology label's location, a number of sentiments emerged. Out of ten participants providing suggestions for label location, six advocated for front-of-package placement and/or with a large display or words. In contrast, the remaining four, three of which were from the same focus group, suggested placing a nanotechnology identifier in the ingredients instead, especially if the nanomaterial is a food additive. Looking more closely, those supporting front-of-package labels did so with different contexts. One called for a large front-of-package label if the "risk" of product usage was high enough, otherwise the participant would likely ignore a label if no notable risk was involved. Alternatively, two others simply wanted the front label to be applied at a product's outset, with one of the two conceding to the label's removal or reduction to "small print" after ten years. The implicit assumption is after enough time a label will not be necessary, given what will presumably be known about nanotechnology. Two other views implicating label location but not widely discussed were the use of a more noticeable print size for children's products (particularly if allergies are implicated), and the application of a nanotechnology symbol.

Front-of-package and large display sizes were the predominant ideas, indicating the label's risk communication purpose, given support from six out of ten label location suggestion comments. Interestingly, consideration of a representative symbol like those for recycling was only covered in one statement and with little emphasis, "*Well you get some really good marketing/advertising person to make the little labels, you know like the recycling thing, a little nanotechnology label*". This logically aligns with participant statements, as when discussing nanotechnology communication and labeling issues, no participants presented the idea of shortcuts or employing concise language. Perhaps, a symbol would not fulfill the goal of sufficient risk communication in participants' eyes, unless the full rationale and implications of a given symbol were already established.

Finally, a small group of statements briefly spoke to label skepticism, which was addressed simultaneously with a label touting benefits. Notions expressed presumed if nanomaterial benefits were displayed on the front, then the risks would be hidden on the back. Moreover, a strong concern existed among a few vocal participants that the risks would be lost among marketing messages talking purely about nanomaterial benefits. Skepticism thus perpetuated negativity regarding industry's role in communication about nanotechnology. As one individual put it, "…if you are forthcoming then you don't have to tell as many lies later." Therefore, the concern that companies will muddy information surrounding product risks or resist labeling altogether if its requirements are too stringent further establishes the label as a risk communication device.

3. Quantitative post-survey results

In the days following completion of each focus group, a quantitative post-survey was emailed to participants of each respective group. The survey fulfilled the purposes of attempting to quantify participant views regarding select topics explored in the groups (e.g., desire for a label), generally comparing and contrasting results with focus group data, and capturing certain ideas not necessarily discussed in each group (e.g., willingness-to-pay or willingness-to-avoid nanotechnology food products). Figures 4.8 through 4.15 display select results of the post-survey relevant to this paper. Electronic post-surveys were completed by 61% (n=34) of the total focus group sample. Although the sample is small, descriptive results are still valuable on their own merit and for comparison with worksheet responses. See Appendix D for the full survey given.

Regarding comfort with the idea of nanotechnology overall, the average response was slightly above "Neither Comfortable/Uncomfortable" at 3.26. The average is partly misleading, since there were more counts for "Fairly Comfortable" (n=17) than for the combination of "Fairly Uncomfortable" (n=6) and "Not comfortable at all" (n=1). No one was compelled to choose "Very Comfortable". The response distribution and averages shift, however, when considering the specific applications of "In food products" (2.71), "In food packaging" (3.41), and "For food processing" (2.76). As similar to the relative comparison of willingness-to-use across these applications, respondents were more comfortable with nanotechnology in food packaging than in food products or for processing. Notably, only food packaging's average was above the neutral response,

which is easily seen by the balance of above-neutral vs. below-neutral response counts: 9 vs. 17 for food products, 19 vs. 7 for food packaging, and 9 vs. 16 for food processing.

When attempting to weigh the benefits vs. the risks, the answer distributions are particularly similar to the answer distributions for "Comfort with nanotechnology". Accordingly, perception of benefits slightly outweighing risks resulted for nanotechnology overall (3.18) and for the application food packaging (3.44), in contrast to risks slightly outweighing benefits for the applications of food products (2.68) and food processing (2.88). Few individuals thought risks strongly outweighed benefits for any category (n=3 for food products and n=2 for food processing), while a correspondingly few perceived benefits strongly outweighing risks across categories (n=3 for food packaging, n=1 for food processing).

Count distributions for labeling preferences were fairly analogous across applications, leading to averages all between "Agree" and "Strongly Agree". Importantly, labeling was most demanded for food products (4.44) in contrast to food packaging (4.06) and food processing (4.29). These results effectively reflect labeling opinions shared across groups, except there is more of a presence of disagreement or ambivalence/neutrality indicated in the post-survey compared to what was voiced during the focus groups (only one individual across all groups actively spoke against a label, and vocalized neutrality was limited). Nevertheless, respondents clearly desire labeling for nanotechnology food applications.

Moving beyond consideration of a label itself is the trust respondents appear to place in the Food and Drug Administration (FDA). For the concern of ensuring safety of food products associated with nanotechnology, responses averaged to 3.35, marginally above "Neither trust nor distrust". On the other hand, when weighing non-neutral counts, above-neutral trust individuals about doubled below-neutral trust individuals (22 vs. 10), with one individual each for "Complete trust" and "Complete distrust". Interestingly, trust in the FDA increased when respondents considered the FDA's ability to ensure effective regulation and enforcement of a nanotechnology label. Trust was higher above neutral at 3.56, with a shifted above-neutral trust vs. below neutral-trust count comparison of 25 vs. 6.

Beyond desire for a label or trust in its regulation, another key issue involves hypothetical cost adjustment due to a nanotechnology label's presence. Following an assumption that adding a nanotechnology label to a product increases its costs, respondents were asked to choose whom they think should shoulder the additional cost (combinations of "Consumers", "Producers", and "Government"). There were two modes (n=11 each), which were "Producers" and "Consumers & Producers". The remaining categories received limited counts, except for "Government" and "Consumers & Government", which each received zero counts. One individual selected "None of them" and three chose "Other". For the latter, supplemented comments all voiced the same sentiment: one way or another, consumers would consequently bear the cost burden.

Extending the hypothetical situation of a label adding extra cost to a nanotechnology product, respondents rated how much more they would be willing to pay to have a product with nanotechnology labeled as such, assuming a starting price of $5.00. Given the fixed choices of various incremental price increases ($0.05, $0.25, $0.50, $0.75, $1.00, $1.25, and over $1.25), the majority of respondents (n=21) were willing to pay *some* additional cost for a label, in contrast to those who would refuse to pay extra for the label (n=13).

Finally, as a useful variation of the willingness-to-pay scenario, willingness-to-avoid a product labeled as containing nanomaterials was investigated. Employing the same price increments as the willingness-to-pay question, respondents chose how much additional cost they would be willing to pay for a product *without* nanomaterials, assuming the identical product *with* nanomaterials and an identifying label cost $5.00. Although more widely distributed across increments, the willingness-to-avoid distribution analogously follows the willingness-to-pay distribution. The majority (n=20) would pay an additional cost for the nanomaterial-free product in contrast to those who would not be willing to pay more (n=14). The most common cost increments selected were the two lowest (n=7 for $0.05 and n=6 for $0.10). Lastly, of particular importance is that of the given price increments, the higher cost options had more counts for willingness-to-avoid a product with nanomaterials than for willingness-to-pay for the label.

Figure 4.8 – Comfort with nanotechnology

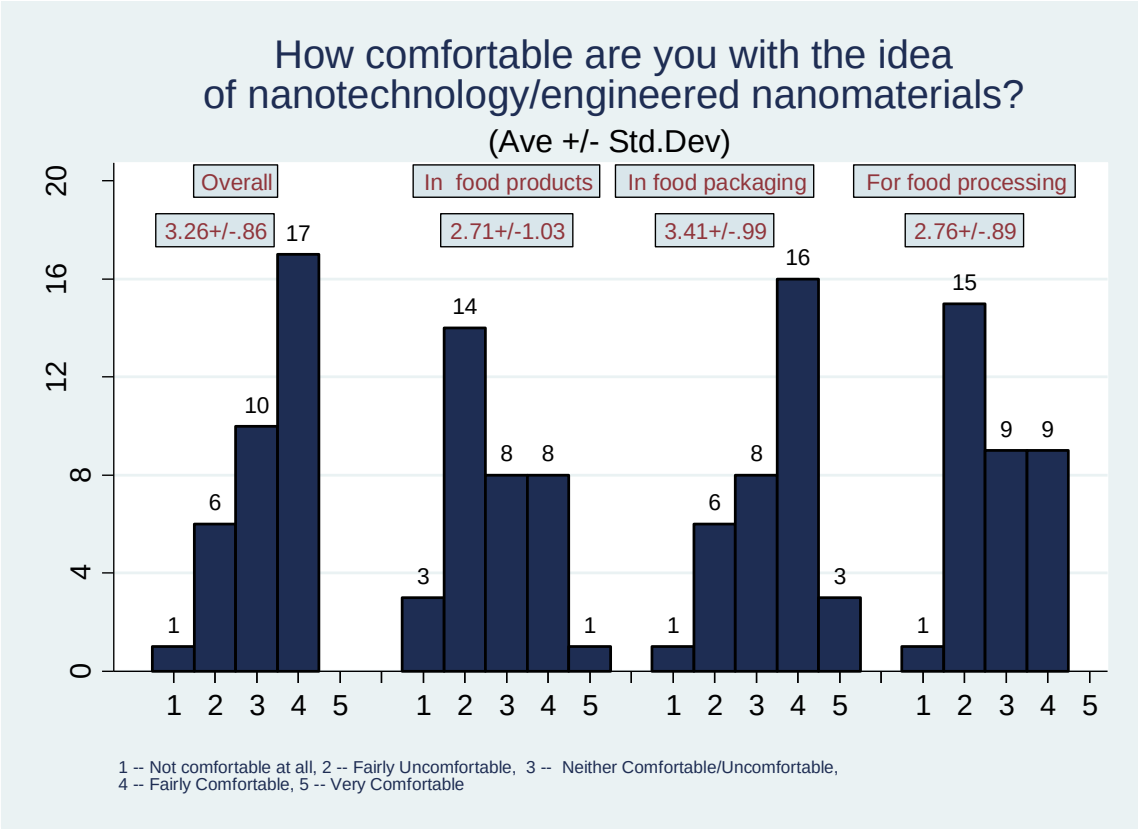


Figure 4.9 – Weighing nanotechnology's benefits vs. risks

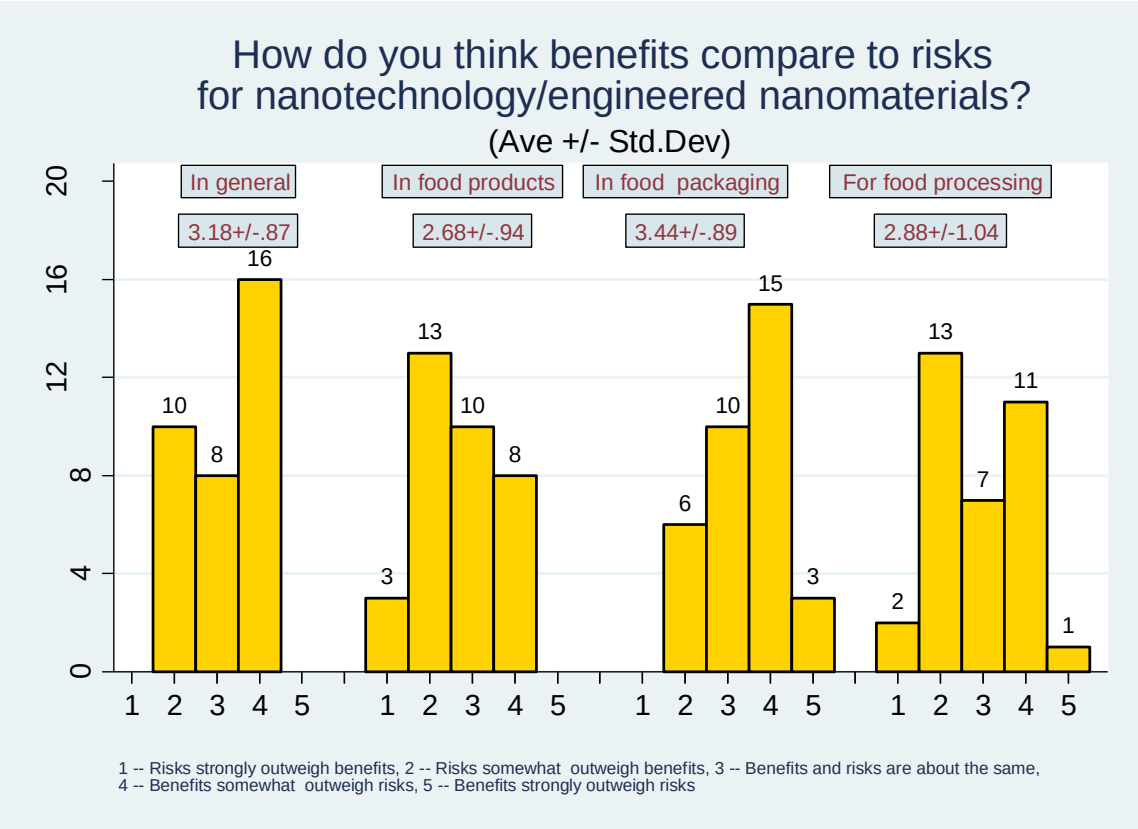
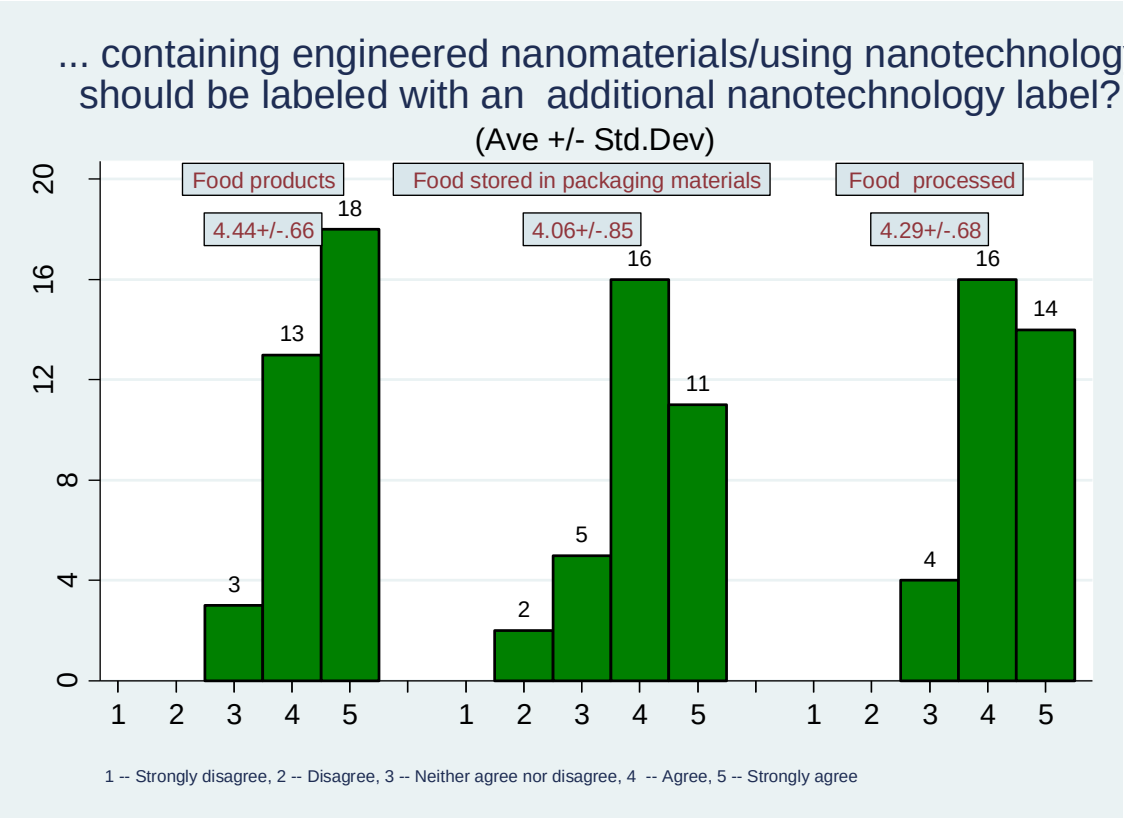


Figure 4.10 – Desire for nanotechnology food product labeling



Figures 4.11 – Trust in the FDA to ensure safety of nanotechnology food products

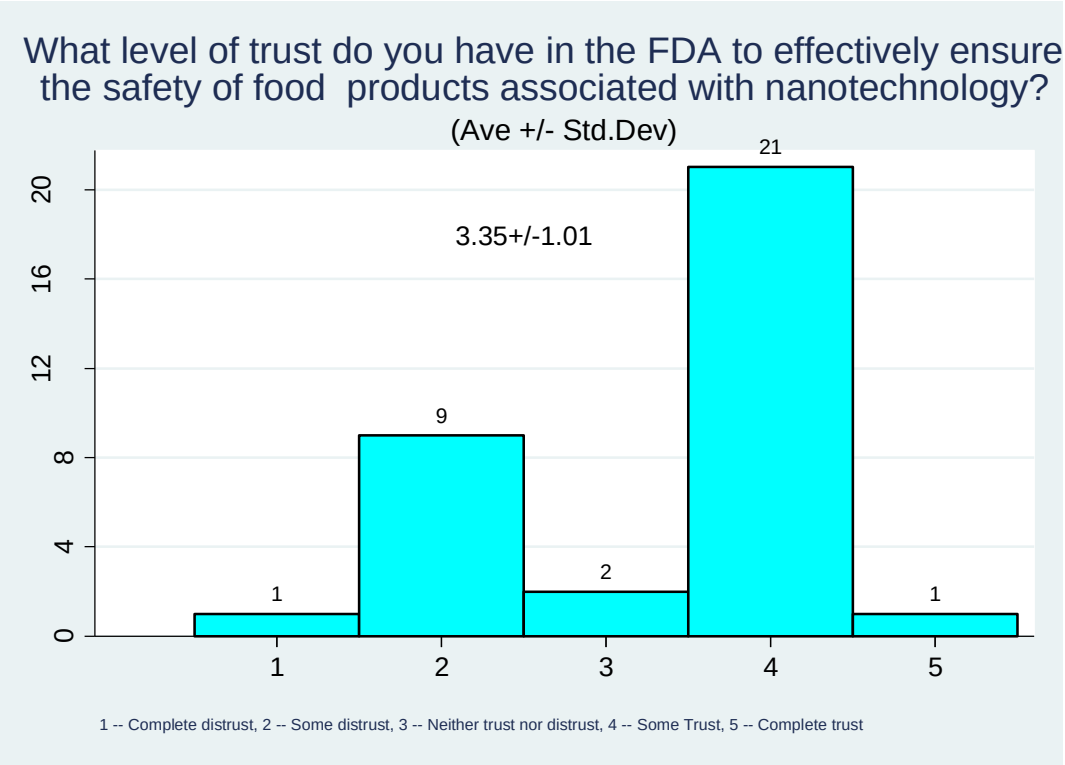


Figure 4.12 – Trust in the FDA to regulate a nanotechnology food product label

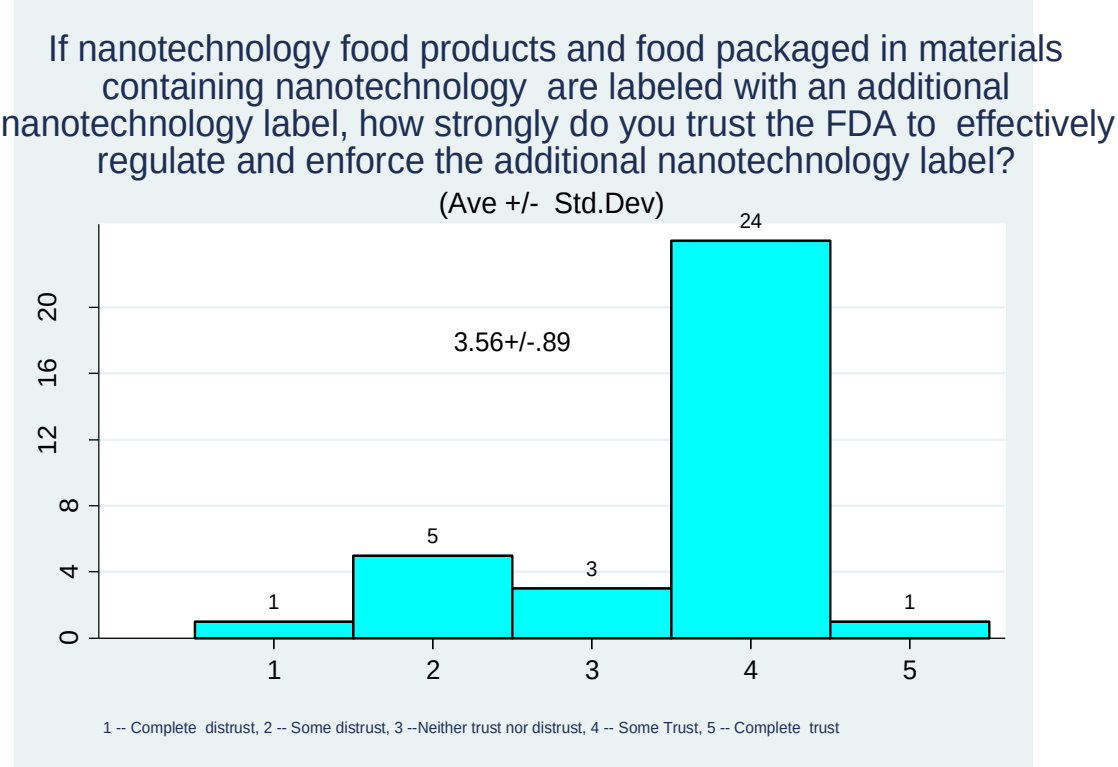


Figure 4.13 – Paying for the cost of a nanotechnology label. Three answered "Other": 1. "*Doesn't matter, consumer will ultimately be paying for it in the end.*" 2. "*The consumer always pays in the end.*" 3. "*Producer will pass to the consumer.*"

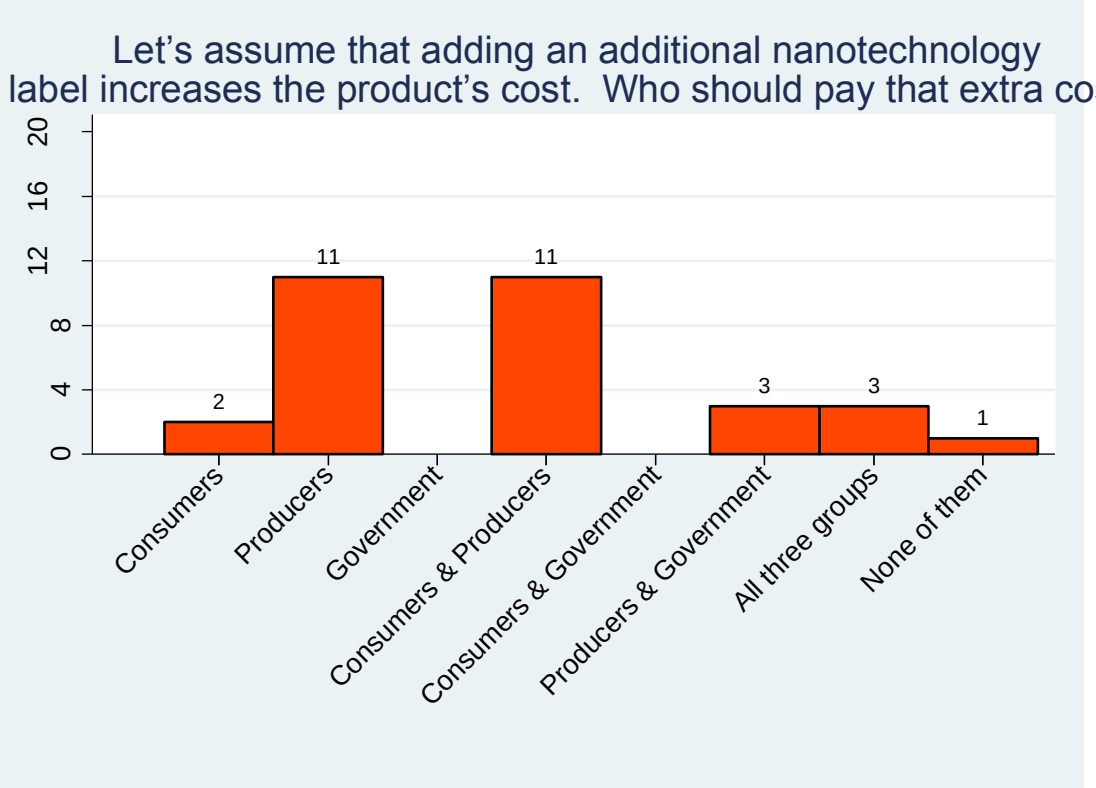


Figure 4.14 – Willingness-to-pay for an additional nanotechnology food product label. "If the cost of the additional nanotechnology label was placed in part or totally on consumers through raising the price of labeled products, what is the maximum increase you would be willing to pay for a product to have it labeled with a nanotechnology label, if the initial cost without the nanotechnology label is $5.00?" Response choices: 1 – *I would not be willing to pay extra for a nanotechnology label. Total Product Price = $5.00*; 2 – *Extra 1% = $0.05. Total Product Price = $5.05;* 3 – *Extra 5% = $0.25. Total Product Price = $5.25*; 4 – *Extra 10% = $0.50. Total Product Price = $5.50*; 5 – *Extra 15% = $0.75. Total Product Price = $5.75*; 6 – *Extra 20% = $1.00. Total Product Price = $6.00*; 7 – *Extra 25% = $1.25. Total Product Price = $6.25*; 8 – *I would be willing to pay more than 25% for the nanotechnology label. Total Product Price = greater than $6.25*.

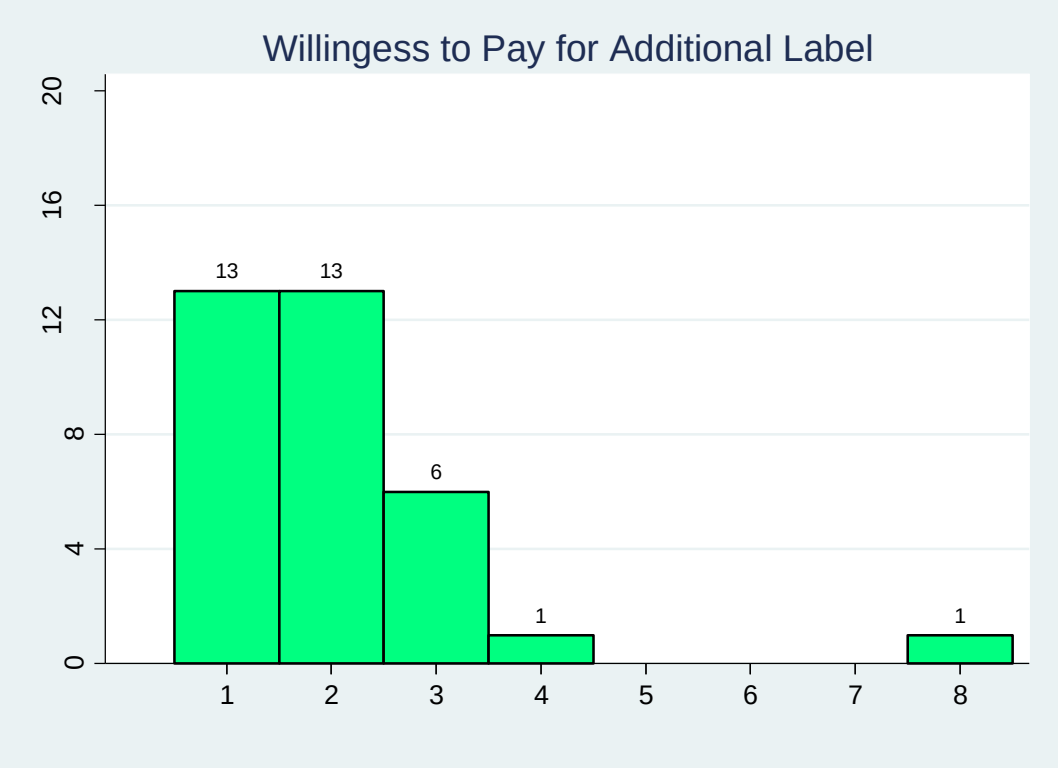
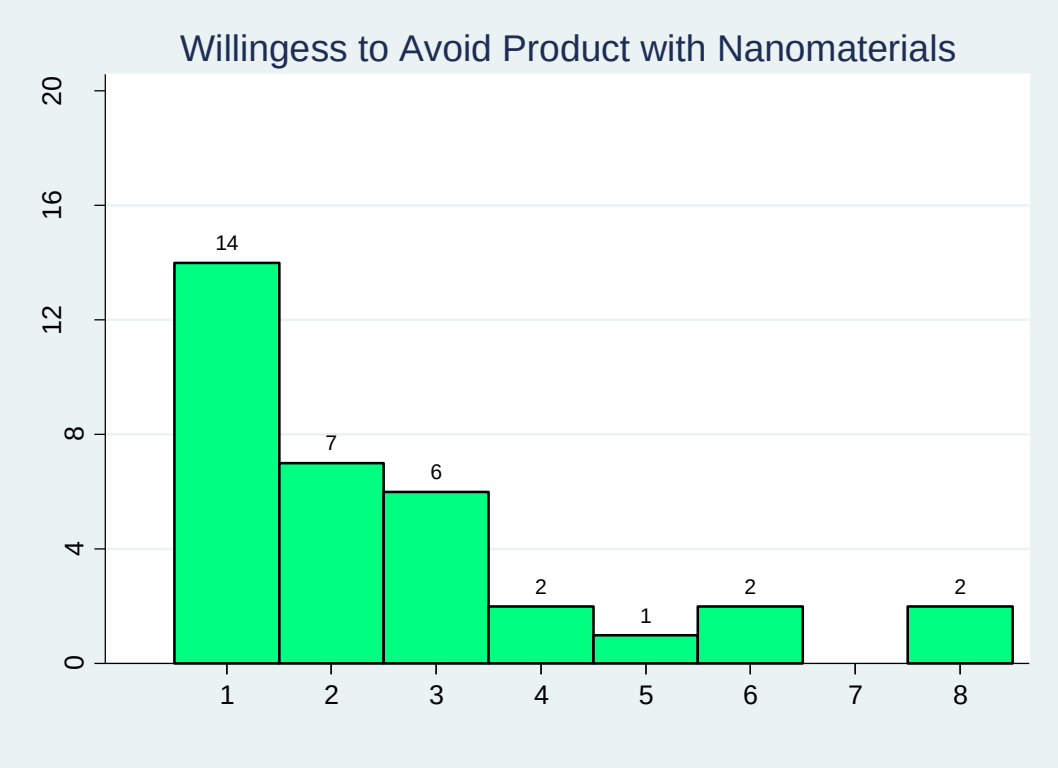


Figure 4.15 – Willingness-to-avoid nanotechnology food products: "Imagine that nanotechnology product labeling is mandatory in the U.S. and that for all products containing nanomaterials, you have the option of buying the product without nanomaterials. If the product containing nanomaterials is $5.00, what is the maximum increase price you would be willing to pay for the product without nanomaterials?" Response choices: 1 – *I would not be willing to pay extra for the product without nanomaterials. Total Product Price = $5.00*; 2 – *Extra 1% = $0.05. Total Product Price = $5.05*; 3 – *Extra 5% = $0.25. Total Product Price = $5.25*; 4 – *Extra 10% = $0.50. Total Product Price = $5.50*; 5 – *Extra 15% = $0.75. Total Product Price = $5.75*; 6 – *Extra 20% = $1.00. Total Product Price = $6.00*; 7 – *Extra 25% = $1.25. Total Product Price = $6.25*; 8 – *I would be willing to pay more than 25% for product without nanomaterials. Total Product Price = greater than $6.25*.



Chapter V: Discussion

1. Study limitations

Several limitations are worth noting that exist within the context of our study and analysis. The small sample size (n=56 for focus groups and worksheet responses; n=34 for the post-survey) reduces inferential power for the quantitative worksheet and post-survey results. For focus groups, however, this is to be expected as the goal is depth of quality discussion and not necessarily creating as large a group or as many groups as possible. Nonetheless, reliable conclusions cannot be definitely drawn from these quantitative results, though they are still valuable as they provide an initial snapshot of many issues heretofore uninvestigated. Additionally, a small sample size coupled with underrepresentation for multiple demographics (e.g., non-Caucasians, females, those under age 40, etc.) restricts generalizability of all results, quantitative and qualitative.

The nature of focus group execution presents further challenges. Since it is an inherently extraverted methodology, introverted individuals may not participate as readily. This potential imbalance skews the discussion toward the extraverted participants' ideas. A technique to mitigate this bias, which was employed by our moderators, is to deliberately direct questions toward quieter participants once a topic is generated. Although directed calling is effective at providing the opportunity for all views on a specific topic to be heard, more talkative participants nonetheless exert essential control as their initial contributions determine the topics to be covered. Extraverts' perspectives will thus be overrepresented in the conversation flow.

Another challenge with employing focus groups deals with moderator-controlled variations. While one discussion guide (i.e., set of specific guiding questions) was used for all focus groups, the moderator frequently had to ask varying follow-up questions to maintain quality, substantive dialogue. Consequently, several impromptu questions stimulating important exchanges were not raised in all groups, leading to a "prompt" bias. Not only does this variation restrict comparison between groups, but topic frequency may serve as an unreliable measure for issues emerging from unequally presented questions. Were all prompts strictly standardized among all groups, the prompt bias would have been completely minimized, though this is an unrealistic condition for focus group studies. Fortunately, such variability was not widely problematic, since all focus groups consisted of the same six phases with the same preliminary prompts.

2. Education of the public

The conclusion reached from the data represented in Figure 4.6 ("Thematic Flow for the Public's Effective Use of a Label") involved a participant desire to be educated about nanotechnology *before* a nanotechnology label is introduced to products, with the education source being consumers themselves or an institution such as government or industry. Further consideration of this pre-policy education is warranted. The natural questions to ask are, "Who should do the educating?" and "How should the education be done?". When considering the context of only focus group discussions and the post-survey, some insight emerges for answering the "Who?" but very little for the "How?".

First, exploring the idea of Individual vs. Institution for education source that emerged in the focus groups holds important implications. Notably, even if one rules on the side of "Individual", the information a consumer would seek must be published and available in the first place. Therefore, a role exists for *some* institution to supply consumer information. On the other hand, one could point to the array of nanotechnology information already available through academic, government, and various organizations' websites. The issue, however, is not simply providing a dumping ground of material for consumers; rather, an accessible and organized clearinghouse relevant to a given nanotechnology labeling policy is what is necessary.

Indeed, comments speaking to the "Individual" approach were in the context of the status quo: no labeling system. If a labeling system is introduced with no accompanying outreach or education, no guarantee exists that "Individual" advocates would be able to usefully find all relevant information through currently published information in order to make a sufficiently informed choice. Moreover, it is wholly unreasonable to assume an FDA-regulated labeling system would be initiated with absolutely no public information, especially when considering the high volume of regulatory information on FDA's website and frequent news coverage of FDA actions and statements. In contrast to this, a voluntary industry- or company-applied labeling scheme may be more of a marketing tactic and rely little on relevantly organized and available information.

Application of the "Individual" approach thus appears to apply primarily to the status quo (no labeling system) or a voluntary labeling system where companies supply limited

information. On the other hand, focus group and survey results demonstrate that neither the status quo nor a producer-based voluntary labeling system were desired. Following this and participant views about a label's purpose and its preferred characteristics, a mandatory and regulated labeling system seems desirable. Therefore, regardless of one's stance about "Individual" vs. "Institutional" educational responsibility, the desire for a regulated system means *some* form of information will be provided to accompany the instituted system. The question of "Who does the educating?" still remains, though insight can be gained from participant statements and select post-survey questions.

Based on focus group discussions, though limitedly discussed, the two major institutions participants referenced who would have a say in nanotechnology product education are government or industry. This reinforces results from a Norwegian study involving advertisements, packaging, and labeling of nanotechnology in cosmetics. In the survey portion, respondents cited "authorities" and then producers as responsible for informing and educating consumers about nanotechnology (Thorne-Holst and Strandbakken 2009). Helping shape this issue is consideration of our survey results and focus group attitudes regarding labeling and regulation. When asked about trust in the FDA to ensure the safety of food products associated with nanotechnology, 22 of 34 respondents indicated some (n=21) or complete (n=1) trust, with only one completely distrusting. Similarly, when presented a hypothetical scenario of nanotechnology food products/packaging containing a nanotechnology-identifying label, 25 of 34 respondents had "some" (n=24) or "complete" (n=1) trust in the FDA to regulate and enforce the additional label.

Furthermore, considering the theme of "Concern for public's interest" and the thread of skepticism about industry in the "Trust" and "Skepticism" themes (see section 4.2.1, for quotes and examples), a potentially strong consumer notion affecting perceptions of the nanotechnology industry is that producers will not share economic benefits of nanotechnology with consumers nor put the public's health and safety ahead of profit. Such perceptions could present a pre-existing barrier to ensuring that the nanotechnology industry is viewed as an effective education/information source able to keep the public's interest as a priority.

Considering all of the survey and focus group responses, a rough, prospective regulatory and outreach picture emerges. One could infer that an FDA-regulated system with government-based education programs regarding the labeling system is an outcome that would foster reasonable public support. However, this needs additional study in the nanotechnology context, given the low survey sample size. In the least, a safe assumption is that government-sponsored outreach would not be overtly rejected.

3. Future directions

Numerous next research steps are evident from this paper's results and limitations. One of the biggest challenges is determining the ideal content for a nanotechnology label. Much research exists regarding multiple aspects of food labels such as consumer use of nutrition labels, processing label health claims, etc., but identifying the best words or phrases to put on a nanotechnology label is a wholly new issue. Consequently, what kinds of words, phrases, and symbols will best facilitate consumers' ability to make an

informed decision? In contrast to open-ended questions, testing several hypothetical phrases, symbols, and locations on the product for consumer comprehension, understanding, and the effect on hypothetical purchasing behavior will build further essential groundwork. Siegrist and Keller 2011 already began such work with Swiss citizens, using surveys to test consumer reactions to various nanotechnology labels on sunscreen when given different risk or benefit information. This approach should be expanded to a US context, testing various product labels on foods with survey and focus groups methods.

Similar to shifting away from open-ended data collection for labeling content exploration, other issues arising during the focus groups will be beneficial to analyze in a closed-response, survey format. Notably, participant variations in how they actually use labels and label effectiveness were a major focus group theme. In order to get a representative idea of potential nanotechnology label usage and effectiveness, closed-ended questions asking for agreement with statements such as "I generally read the labels on the front of a food product", "If a nanotechnology label were placed on a food product, I would read it", and other variants would be beneficial. Not only will such studies add quantitative evidence to be tested against these qualitative results, but perceptions will be solidified in a more purposeful manner, in contrast to the exploratory style of focus groups.

Related to label content and consumer understanding is the matter of public outreach if a regulated labeling policy is implemented. Questions beyond, "Who should conduct the outreach?", as discussed above, include, "What methods of education should be

pursued?" and, "How much is necessary?". Various communication modes such as web, television, radio, and print media demand attention and consideration to see how many and how well consumers may be reached by an outreach message related to food labels and emerging technologies. Investigation into trust and believability of message source in the context of emerging technologies is also warranted.

Lastly, several of the post-survey questions are worth expanding into a larger quantitative study with a much bigger sample size. Topics of particular and immediate relevance to nanotechnology labeling policy development and the food industry that should be examined in future surveys include consumer desire for a label across food products (across particular product categories as well), trust in the FDA to regulate and enforce a labeling policy, and consumer willingness-to-pay and willingness-to-avoid food products both with and without nanomaterials that involve a product label and different adjustments in product costs.

Chapter VI: Conclusions

Investigating public perception of nanotechnology in food, particularly labeling issues, using focus groups, an in-group survey, and a post-survey revealed several insights presented in the results and discussion. Conclusions relevant to food product labeling with a few generalized nanotechnology perception results are summarized as follows.

Based on in-group worksheets, participants were most willing to use nanotechnology in packaging, compared to nanotechnology in food additives or processing applications. Preference for packaging above other applications confirms a similar finding by Siegrist *et al.,* 2007. When comparing willingness-to-use for functions of applications, reducing spoilage and enhancing nutrition were rated more highly than enhancing experience and cheaper production. The former two speak to more practical or health benefits, while cheaper production may have been disregarded following a presumption that cost reductions would not be passed along to the consumer. A handful of statements in the focus groups and additional comments on the labeling cost post-survey question provide evidence for this presumption's existence.

Labeling discussions activated numerous topics related and unrelated to nanotechnology food product labeling. The nature of focus groups facilitated the emergence of discussions unrelated to labeling from moderator prompts explicitly about nanotechnology food labeling. Frequently discussed themes during the labeling phase not necessarily related to nanotechnology product labeling included labeling of existing non-nanotechnology products (e.g., cigarette or drug warnings), various perceived risks,

willingness or not to use products with nanomaterials, public skepticism of nanotechnology (with several individuals voicing doubts or critiques of multiple aspects of nanotechnology such as industry's potential lack of concern for the public and the challenges in creating a product label), other kinds of product labels (e.g., allergy warnings), mixed trust in stakeholders such as industry and the FDA (though more post-survey participants trusted the FDA than did not), benefits discussed directly (but only regurgitated from background information and not generated by the participant originally) and indirectly through the context of other themes, industry's lack of concern for the public's interest, safety testing mainly in the context of its necessity for nanotechnology but that eventually enough is enough, past mainstream health information, and nutrition and health more broadly.

Essential themes raised regarding nanotechnology food product labeling included label preferences, factors moderating consumers' use of a label, information sources (to understand nanotechnology and potential product labels), and skepticism for nanotechnology products and their labeling.

Sub-themes of label preferences consisted of consumer desire for a label, perceived label usage and purpose, and preferred labeling characteristics. More specifically, most participants desire a label on nanotechnology food products with only one participant indicating a preference against such a label, while a few others were unsure, had mixed reactions, or were apathetic. Additionally, a label's main purpose emerged as an informational device, equipping consumers with the ability to make an autonomous

purchasing decision. As far as communicating such information, strong preference emerged for a prominent, front-of-package label, while a few suggested use of the ingredients section.

Label effectiveness and its impact on consumer behavior, regulation perception, and consumer choice perception were sub-themes comprising label use moderators. Among those reading labels at all, a label was viewed as effective when the information on the label was understandable, invoking consumer choice, as an effective label allows consumers to make an autonomous purchasing choice. Merging themes and as shown in Figure 4.7, using a label to empower autonomous decision-making reveals the participant view that this is viewed as a label's main purpose. Regulation perceptions demonstrated mixed views on the FDA, with some showing trust, fewer showing distrust, and a minority view conceding that the FDA will regulate without considering public opinion.

Education and information sources were dichotomized into institution- or personally-based sub-themes, with the former placing responsibility on external groups such as governments to engage in outreach and education, and the latter assuming individuals should take initiative to learn about nanotechnology. Response counts and attention given to institution- and personally-based information sources were balanced across both.

Skepticism arose in the labeling context and was not subdivided into smaller themes, though a salient comment in this theme voiced doubt that the FDA will require nanotechnology product labeling.

Established in focus group discussions with support from the post-survey, participants nearly unanimously want nanotechnology food product labeling, generally for reasons of needing information in order to make an informed purchasing decision. Only one person voiced opposition to labeling on grounds of risking a false sense of safety, while those voicing apathy did so due to their not reading labels in the first place. Following this, participants were very aware of their own nanotechnology understanding gap and often spoke to the matter of needing more information and education about nanotechnology or else the label would not be beneficial.

Regarding educational responsibility, participants mostly cited government, industry, or individual consumers as the entities accountable. Irrespective of preferred education source, if desired product labeling falls under a mandatory government regulated system, some form of education or outreach must occur in order for consumers to effectively use and make decisions using a new label. Post-survey results indicate, albeit weakly due to low sample size, there exists sufficient trust in the FDA to regulate and enforce nanotechnology food product labels and safety. Thus, following focus group comments and post-survey results, the FDA appears to be a potentially effective source for public education and outreach for nanotechnology products and labels.

Considering willingness-to-pay and willingness-to-avoid issues from the post-survey, the majority of respondents indicated a willingness-to-pay for an additional nanotechnology product label and also would pay additional price increases to avoid purchasing a food

product containing nanomaterials. This seems to be in accordance with focus group statements, in which only two participants vocalized support for paying more for a nanotechnology product, on the grounds that additional product benefits would arise from a nanomaterial's inclusion.

Diving deeper into participant perspectives and merging major labeling themes reveals that a nanotechnology label is likely perceived as a risk heuristic. This perception has implications for thinking about preferred labeling content and characteristics. Although a front-of-package label was spoken to most clearly, content suggestions were widely variable with no obvious consensus nor a favored phrase or symbol. Therefore, though label presence is unequivocally desired, there are limited, well-formulated perspectives about the label itself. In order to best take advantage of participant content and characteristic suggestions, such responses should be inserted into a closed-ended survey format or applied to creating several sample labels on actual products to be used in a survey and/or deliberative technique.

Overall, much potential exists to adapt focus group results and expand post-survey questions into future larger closed-ended surveys. These results present needed groundwork and a wide range of topics to consider for a nanotechnology food product labeling policy, but more must be investigated. Focusing on select issues through surveys with large sample sizes will supply inferential power to public preferences related to labeling content, labeling characteristics, willingness to pay for a nanotechnology product label, and willingness to avoid food products with

nanomaterials, among other subjects. Additionally, employing future focus groups or other deliberative techniques to evaluate sample labels, test education and outreach messages, and further derive rationale behind public thought will provide salient contributions to nanotechnology food product labeling policy that will be effective for and in the eyes of consumers.

Bibliography

Berube, David M. *Nano-hype: The Truth behind the Nanotechnology Buzz*. Amherst, NY: Prometheus, 2006. Print.

Besley, John. "Current Research on Public Perceptions of Nanotechnology." *Emerging Health Threats Journal* 3 (2010). Web.

Bouwmeester, H., S. Dekkers, M. Noordam, W. Hagens, A. Bulder, C. Deheer, S. Tenvoorde, S. Wijnhoven, H. Marvin, and A. Sips. "Review of Health Safety Aspects of Nanotechnologies in Food Production." *Regulatory Toxicology and Pharmacology* 53.1 (2009): 52-62. Web.

Burri, Regula Valérie. "Deliberating Risks Under Uncertainty: Experience, Trust, and Attitudes in a Swiss Nanotechnology Stakeholder Discussion Group." *NanoEthics* 1.2 (2007): 143-54. Web.

Buzby, JC. "Nanotechnology for Food Applications. More Questions than Answers." *Journal of Consumer Affairs* 44.3 (2010): 528-45. Web.

Cardello, Armand V. "Consumer Concerns and Expectations about Novel Food Processing Technologies: Effects on Product Liking." *Appetite* 40.3 (2003): 217-33. Web.

Cardello, A., H. Schutz, and L. Lesher. "Consumer Perceptions of Foods Processed by Innovative and Emerging Technologies: A Conjoint Analytic Study." *Innovative Food Science & Emerging Technologies* 8.1 (2007): 73-83.Web.

Carey, M.A. “The group effect in focus groups: planning, implementing and interpreting focus group research.” Critical Issues in Qualitative Research Methods. Ed. J Morse. CA: Sage, 1994. 225-241.

Carey, M.A., and M.W. Smith. "Capturing the Group Effect in Focus Groups: A Special Concern in Analysis." *Qualitative Health Research* 4.1 (1994): 123-27. Web.

Chau, C., S. Wu, and G. Yen. "The Development of Regulations for Food Nanotechnology." *Trends in Food Science & Technology* 18.5 (2007): 269-80. Web.

Chaudhry, Qasim, Michael Scotter, James Blackburn, Bryony Ross, Alistair Boxall, Laurence Castle, Robert Aitken, and Richard Watkins. "Applications and Implications of Nanotechnologies for the Food Sector." *Food Additives & Contaminants* 25.3 (2008): 241-58. Web.

Chun, A.L. "Will the Public Swallow Nano Food?" *Nature Nanotechnology* 4.12 (2009): 790-91. Web.

Cook, Andrew J., and John R. Fairweather. "Intentions of New Zealanders to Purchase Lamb or Beef Made Using Nanotechnology." *British Food Journal* 109.9 (2007): 675-88. Web.

Currall, Steven C. "Nanotechnology and Society: New Insights into Public Perceptions." *Nature Nanotechnology* 4.2 (2009): 79-80. Web.

Department for Environment, Food and Rural Affairs (Defra). *UK Voluntary Reporting Scheme for Engineered Nanoscale Materials*. Department for Environment, Food and Rural Affairs, 2008. Web. <http://archive.defra.gov.uk/environment/quality/nanotech/documents/vrs-nanoscale.pdf>.

D'Silva, Joel, and Diana M. Bowman. "To Label or Not to Label? - It's More than a Nano-Sized Question." *European Journal of Risk Regulation* 4 (2010): 420-27. Web.

Dudo, Anthony, Doo-Hun Choi, and Dietram A. Scheufele. "Food Nanotechnology in the News. Coverage Patterns and Thematic Emphases during the Last Decade." *Appetite* 56.1 (2011): 78-89. Web.

Falkner, R., L. Breggin, N. Jaspers, J. Pendergrass, and R. Porter. *Consumer Labelling of Nanomaterials in the EU and US: Convergence or Divergence?* London: Chatham House, 2009. *LSE Research Online*. 2009. Web. <http://eprints.lse.ac.uk/25422/>.

Farhang B. "Nanotechnology and Applications in Food Safety." Global Issues in Food Science and Technology. Ed. Gustavo Barbosa-Cánovas, Alan Mortimer, David Lineback, Walter Spiess, Ken Buckle, and Paul Colonna. Amsterdam: Academic Press, 2009. 401–410.

House of Lords, Science and Technology Committee. *Nanotechnologies and food*. Authority of the House of Lords, 2010. Web. <http://www.publications.parliament.uk/pa/ld200910/ldselect/ldsctech/22/22i.pdf>.

Kohler, Andreas, and Claudia Som. "Environmental and Health Implications of Nanotechnology—Have Innovators Learned the Lessons from Past Experiences?" *Human and Ecological Risk Assessment* 14.3 (2008): 512-31. Web.

Krueger, Richard A., and Mary Anne. Casey. *Focus Groups: A Practical Guide for Applied Research*. Los Angeles: Sage Publications, 2009. Print.

Kuzma, Jennifer, and John C. Besley. "Ethics of Risk Analysis and Regulatory Review: From Bio- to Nanotechnology." *NanoEthics* 2.2 (2008): 149-62. Web.

Kuzma, Jennifer, James Romanchek, and Adam Kokotovich. "Upstream Oversight Assessment for Agrifood Nanotechnology: A Case Studies Approach." *Risk Analysis* 28.4 (2008): 1081-098. Web.

Kuzma, Jennifer and Peter Verhage. *Nanotechnology in Agriculture and Food Production: Anticipated Applications*. Woodrow Wilson International Center for Scholars, Project on Emerging Nanotechnologies 4 (2006). Web. <http://www.nanotechproject.org/process/assets/files/2706/94_pen4_agfood.pdf>.

Macoubrie, J. "Nanotechnology: Public Concerns, Reasoning and Trust in Government." *Public Understanding of Science* 15.2 (2006): 221-41. Web.

Monica, John C. "FDA Labeling of Cosmetics Containing Nanoscale Materials." *Nanotechnology Law and Business* 5.1 (2008): 63-72. Web.

Morgan, David L. "Focus Groups." *Annual Review of Sociology* 22.1 (1996): 129-52. Web.

Morgan, D.L., and Krueger, R.A. "When to use focus groups and why." Successful focus groups: Advancing the state of the art. Ed. D.L. Morgan, Newbury Park, California: Sage Publications, 1993. 3-19. Web.

Office of Basic Energy Sciences. "The Scale of Things - Nanometers and More." Chart. Office of Science, Department of Energy, 2006. Web. <http://science.energy.gov/~/media/bes/pdf/scale_of_things_26may06.pdf>.

Pape, S. B. ""May Contain" Labelling: Adequate Consumer Warning or Unnecessarily Defensive Manufacturer Behaviour?" *Journal of Consumer Policy* 32.2 (2009): 165-88. Web.

Project on Emerging Nanotechnologies (PEN). *Nanotechnology Consumer Products Inventory*. Woodrow Wilson International Center for Scholars, Project on Emerging Nanotechnologies, 2012. Web. <http://www.nanotechproject.org/inventories/consumer/>.

Pidgeon, N., B. Harthorn, K. Bryant, and T. Rogers-Hayden. "Deliberating the Risks of Nanotechnology for Energy and Health Applications in the US and UK." *Nature Nanotechnology* 4.2 (2009): 95-98. Web.

Pidgeon, Nick, and Tee Rogers-Hayden. "Opening up Nanotechnology Dialogue with the Publics: Risk Communication or 'upstream Engagement'?" *Health, Risk & Society* 9.2 (2007): 191-210. Web.

Royal Society and Royal Academy of Engineering. *Nanoscience and Nanotechnologies: Opportunities and Uncertainties*. Royal Society, 2004. Web. <http://www.nanotec.org.uk/finalReport.htm>.

Sanguansri, P., and M. Augustin. "Nanoscale Materials Development – a Food Industry Perspective." *Trends in Food Science & Technology* 17.10 (2006): 547-56. Web.

Satterfield, Terre, Milind Kandlikar, Christian E. H. Beaudrie, Joseph Conti, and Barbara Herr Harthorn. "Anticipating the Perceived Risk of Nanotechnologies." *Nature Nanotechnology* 4.12 (2009): 4752-758. Web.

Scheufele, Dietram A., Elizabeth A. Corley, Tsung-jen Shih, Kajsa E. Dalrymple, and Shirley S. Ho. "Religious Beliefs and Public Attitudes toward Nanotechnology in Europe and the United States." *Nature Nanotechnology* 4.2 (2008): 91-94. Web.

Siegrist, M. "Factors Influencing Public Acceptance of Innovative Food Technologies and Products." *Trends in Food Science & Technology* 19.11 (2008): 603-08. Web.

Siegrist, Michael. "Predicting the Future: Review of Public Perception Studies of Nanotechnology." *Human and Ecological Risk Assessment: An International Journal* 16.4 (2010): 837-46. Web.

Siegrist, M., ME Cousin, H. Kastenholz, and A. Wiek. "A. Public Acceptance of Nanotechnology Foods and Food Packaging: The Influence of Affect and Trust." *Appetite* 49.2 (2007): 459-66. Web.

Siegrist, M., and C. Keller. "Labeling of Nanotechnology Consumer Products Can Influence Risk and Benefit Perceptions." *Risk Analysis* 31.11 (2011): 459-66. Web.

Siegrist, Michael, Nathalie Stampfli, and Hans Kastenholz. "Acceptance of Nanotechnology Foods: A Conjoint Study Examining Consumers' Willingness to Buy." *British Food Journal* 111.7 (2009): 660-68. Web.

Stokes, Elen. "Regulating Nanotechnologies: Sizing up the Options." *Legal Studies* 29.2 (2009): 281-304. Web.

Throne-Holst, Harald, and Pål Strandbakken. "“Nobody Told Me I Was a Nano-Consumer:” How Nanotechnologies Might Challenge the Notion of Consumer Rights." *Journal of Consumer Policy* 32.4 (2009): 393-402. Web.

U.S. FDA. *Nanotechnology: A Report of the U.S. Food and Drug Administration Nanotechnology Task Force*. US Food and Drug Administration, 2007. Web.
<http://www.fda.gov/nanotechnology/taskforce/report2007.html>.

Yawson, Robert M., and Jennifer Kuzma. "Systems Mapping of Consumer Acceptance of Agrifood Nanotechnology." *Journal of Consumer Policy* 33.4 (2010): 299-322. Web.

Appendix A: Focus Group Discussion Guide

Stage I: Priming

Step 1: Start with initial open-ended question to which respondents will quietly write down their answers:

1. What comes to mind when you hear the word "nanotechnology"?

Step 2: Moderator collects written answers and initiates discussion about participants' responses

Step 3: Moderator reads a prepared background document covering two topics; participants will receive the background document as a handout after the moderator finishes reading:

- General nanotechnology information document [see Appendix B]

Step 4: Follow-up question for discussion:

2. What are your thoughts about nanotechnology now? Did any thoughts change?

Stage II: Nanotechnology Food and Agriculture Products

Pre Step: Moderator reads a prepared background document covering two topics; participants will receive the background document as a handout after the moderator finishes reading:

- Nanotechnology in food products and packaging document [see Appendix B]

Step 1: Start with questions for discussion:

3. **What additional benefits and opportunities do you think there are for nanotechnology-based food and agriculture products?**
4. **What about additional concerns for nanotechnology-based food and agriculture products?**

Step 2: Distribution of product category work sheet:

Step 3: Participants fill out work sheet and then discuss their responses, which attempts to get at following question:

5. **What products were you most and least willing to use? Why?**

Stage III: Labeling

Step 1: Continue with discussion questions:

6. **Should these products with nanomaterials be labeled as having nanomaterials? Why?**
7. **Which product categories are most important to label? Why?**
8. **How would the presence of a label change your willingness to buy a nanotechnology-based food or agriculture product?**

Step 2: Additional questions if time permitting:

9. **What if these products were more expensive as a result of labeling? What is your willingness to buy these products? (closed responses on a survey would list additional cost amounts and an original price as a baseline reference)**
10. **Where would you like to see the label on the product?**
11. **What content would you like on the label?**

Appendix B: In-group Informational Documents

Nanotechnology Overview

Nanotechnology is a broad term that encompasses a variety of science and technology at a very small *scale*: nanotechnology refers to the manipulation of matter at the *nanoscale*. A "nanometer" (nm) equals one-billionth of a meter, the width of ten hydrogen atoms side-by-side. By comparison, a DNA molecule (genetic material of living organisms) is about 2.5 nm wide and a red blood cell is about 5,000 nm in diameter. Nanotechnology refers to a suite of techniques used to manipulate matter with precision at the scale of atoms and molecules. At the nanoscale, only the most powerful microscopes are able to actually see objects. (See Fig. 1 for a length scale with examples of different objects at different sizes.)

A critically important aspect of manipulating matter at the nanoscale (below 1000 nm) is that a material's properties can change, even a very familiar material. That is, at the nanoscale, materials can exhibit new properties, such as electrical conductivity, elasticity, enhanced strength, different colors, and different reactivity, when compared to the same material at the "normal" scale. This means, among other things, that using materials at the nanoscale can signify the creation of new materials that can be beneficial in many ways. It also means we cannot assume that materials that are safe and harmless at larger scales are necessarily safe and harmless at the nanoscale.

One example of a novel and widely applicable nanomaterial is the carbon nanotube (CNT). A CNT is a sheet of graphite (carbon atoms) simply wrapped into a tube shape .Notably, CNTs are the strongest and stiffest materials ever created while being fairly light, in addition to exhibiting other useful electrical, optical, and thermal properties. As a result of these beneficial characteristics, CNTs are already in sports equipment, computers, building materials, and vehicles. Despite the positive prospect of CNT products, concerns exist over the safety of CNTs. Studies indicate that CNTs can cause inflammation and other problems in the lungs, as well as skin damage when applied directly. Many experts believe that more research needs to be done to determine the potential risk to human and environmental health and safety stemming from CNTs in different applications.

Outside of CNTs, general nanotechnology advances are leading to current and proposed applications in numerous areas such as medicine and cosmetics. In the medical field, products and discoveries resulting from nanotechnology include new diagnostic tests, product materials for dental fillings and bone replacement, medical tools, and drugs for high cholesterol, appetite control, hormone therapy, and cancer, among others. Cancer drugs are being developed with nanotechnology that target tumor cells specifically. Many sunscreens already contain nanoparticles, which make them more transparent when applied to the skin. The potential risks of nanomaterials to human health and the environment were recently reviewed by many national and international expert groups and the consensus is generally that more research needs to be done to establish the actual risks of nanomaterials in all applications. Current studies on the risks of nanomaterials

do not reflect real-world applications and are typically done on mice under artificial laboratory conditions.

Nanotechnology in Food and Agriculture

Like other sectors, nanotechnology promises to revolutionize the whole food system – from food production to processing, storage, and development of innovative materials, products and applications. For example, nanomaterials in food products could allow color and flavor additives to be added without additional fats or other chemical agents. Nanosized and nano-encapsulated ingredients and additives could improve and create new tastes, flavors and textures. They also can enhance certain foods' nutritional value and can help increase nutrient uptake and absorption in the body. Although the potential applications of nanotechnology are wide ranging, the current applications in the food and agriculture sectors are relatively few. An overview of more than 1,000 nanotechnology-based consumer products that are currently available worldwide suggests that only around 9 percent of these are food and beverage products. Some examples include cocoa nanoparticles to improve taste of chocolate shakes, nanoparticles directly put in food to deliver health fish oils in bread without a fishy taste, and nanoparticles to deliver healthy plant cholesterol in cooking oil.

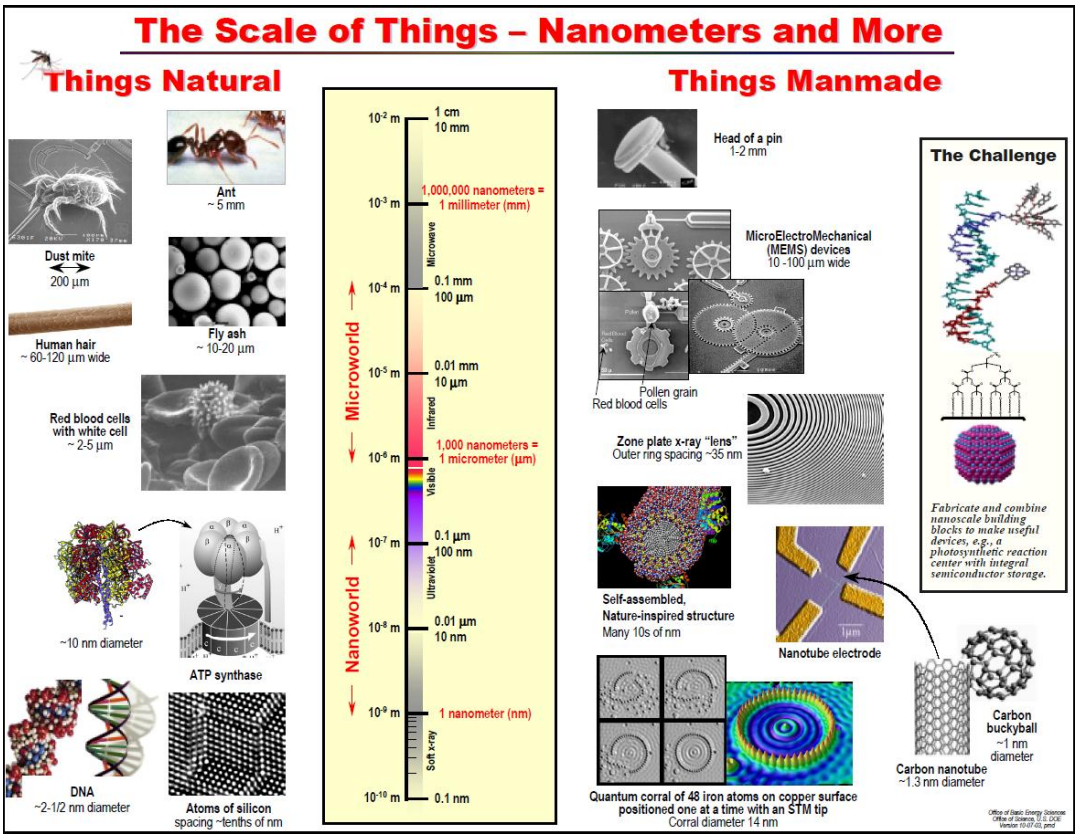
Other key application areas, beside foods themselves, are food packaging and processes to manufacture food, which currently play the largest role in nanotechnology food and agriculture applications. Of the total dollar value of all nanotechnology food applications in 2006, food ingredients comprised 24 percent, food processing 24 percent, and food packaging over 50 percent. Nanomaterial research for food packaging is currently aimed at those materials that come in contact with the food. Potential benefits to the package itself include better strength, flexibility, gas barrier properties (to keep food fresher), and temperature/moisture stability. Other potential benefits include packaging materials with antimicrobial properties for increased food safety, improved package biodegradability, and inclusion of sensors that detect and maintain the safety and quality of the food. In fact, food packaging materials with silver nanoparticles to kill bacteria and make food stay fresh longer are already available on the market.

While nanotechnologies offer many opportunities for innovation, the use of nanomaterials in food has raised a number of safety, environmental, ethical, policy, and regulatory issues. The main issues relate to the potential effects and impacts on human health and the environment that might arise from exposure to nanomaterials. In many products and applications, such as plastic materials for food packaging, nanomaterials may be incorporated in a fixed, bound or embedded form, and hence may not pose significant risk to consumer health or the environment (unless some hazardous particles migrate out during use or disposal). Other applications may pose a greater risk of exposure for consumers to free engineered nanomaterials; for example, certain foods and beverages may contain free floating nanoparticles or a nanopesticide formulation that may be released deliberately into the environment.

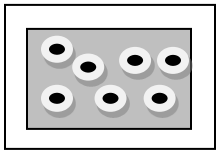
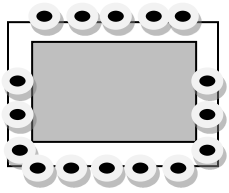
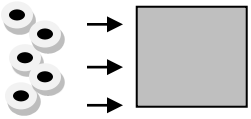
Some studies suggest that if humans are exposed to certain nanoparticles, those particles could end up in parts of the body that larger versions of those particles cannot reach. Examples include nanoparticles passing cellular, blood-brain, and placental

barriers, or accumulating in organs such as the kidney, spleen, or liver. Most experts agree that more studies are therefore needed to determine how nanotechnology applications such as nanoparticles act in food products, the human body, and the environment.

Figure A.1 – Information image presented during reading of general nanotechnology background material (Office of Basic Energy Sciences, 2003).



Appendix C: In-group Worksheet

Product Category	**Nanomaterial's Purpose**	*Benefits*	*Concerns*	*Willingness To Use* *(please circle your choice)*
Food additive **In** 	Enhance Experience (e.g., flavor/color)			1 2 3 4 5
	Enhance Nutrition			1 2 3 4 5
	Prevent/Reduce Spoilage			1 2 3 4 5
	Cheaper Production			1 2 3 4 5
Packaging **On** 	Enhance Experience (e.g., flavor/color)			1 2 3 4 5
	Enhance Nutrition			1 2 3 4 5
	Prevent/Reduce Spoilage			1 2 3 4 5
	Cheaper Production			1 2 3 4 5
Processing **For** 	Enhance Experience (e.g., flavor/color)			1 2 3 4 5
	Enhance Nutrition			1 2 3 4 5
	Prevent/Reduce Spoilage			1 2 3 4 5
	Cheaper Production			1 2 3 4 5

Note-- "Willingness to Use" scale: 1 – Strongly unwilling to use 2 – Unwilling to use 3 – Neither willing nor unwilling 4 – Willing to use 5 – Strongly willing to use

Appendix D: Post-group Online Survey

An email with a link to the following survey was sent to each focus group participant, following completion of their respective focus groups. See Section III for full explanation.

1. Since the focus group ended, how much time have you spent searching for or reading about nanotechnology in general?
   1 – No time at all
   2 – Between 0 and 30 minutes
   3 – Between 30 minutes and 1 hour
   4 – Between 1 hour and 3 hours
   5 – More than 3 hours

2. Since the focus group ended, how much time have you spent searching for or reading about nanotechnology in food and agriculture?
   1 – No time at all
   2 – Between 0 and 30 minutes
   3 – Between 30 minutes and 1 hour
   4 – Between 1 hour and 3 hours
   5 – More than 3 hours

3. How comfortable are you with the idea of nanotechnology overall?
   1 – Not comfortable at all
   2 – Fairly Uncomfortable
   3 – Neither Comfortable/Uncomfortable
   4 – Fairly Comfortable
   5 – Very Comfortable

4. How comfortable are you with the idea of engineered nanomaterials food **products**?
   1 – Not comfortable at all
   2 – Fairly Uncomfortable
   3 – Neither Comfortable/Uncomfortable
   4 – Fairly Comfortable
   5 – Very Comfortable

5. How comfortable are you with the idea of engineered nanomaterials in food **packaging**?
   1 – Not comfortable at all
   2 – Fairly Uncomfortable
   3 – Neither Comfortable/Uncomfortable
   4 – Fairly Comfortable
   5 – Very Comfortable

6. How comfortable are you with the idea of nanotechnology being applied to food **processing**?
   1 – Not comfortable at all
   2 – Fairly Uncomfortable
   3 – Neither Comfortable/Uncomfortable
   4 – Fairly Comfortable
   5 – Very Comfortable

7. How do you think benefits compare to risks for nanotechnology in general (scaled response: one end for benefits strongly outweighing risks, the other end vice versa)
   1 – Risk strongly outweigh benefits

2 – Risks somewhat outweigh benefits
3 – Benefits and risks are about the same
4 – Benefits somewhat outweigh risks
5 – Benefits strongly outweigh risks

8. How do you think benefits compare to risks for food **products** containing engineered nanomaterials?

1 – Risk strongly outweigh benefits
2 – Risks somewhat outweigh benefits
3 – Benefits and risks are about the same
4 – Benefits somewhat outweigh risks
5 – Benefits strongly outweigh risks

9. How do you think benefits compare to risks for food **packaging** containing engineered nanomaterials?

1 – Risk strongly outweigh benefits
2 – Risks somewhat outweigh benefits
3 – Benefits and risks are about the same
4 – Benefits somewhat outweigh risks
5 – Benefits strongly outweigh risks

10. How do you think benefits compare to risks for food **processing** that uses nanotechnology?

1 – Risk strongly outweigh benefits
2 – Risks somewhat outweigh benefits
3 – Benefits and risks are about the same
4 – Benefits somewhat outweigh risks
5 – Benefits strongly outweigh risks

For questions 11 through 13, please indicate your level of agreement with the following statements:

11. Food products containing engineered nanomaterials should be labeled with an additional nanotechnology label.

1 – Strongly disagree
2 – Disagree
3 – Neither agree nor disagree
4 – Agree
5 – Strongly Agree

12. Food stored in packaging materials containing engineered nanomaterials should be labeled with an additional nanotechnology label.

1 – Strongly disagree
2 – Disagree
3 – Neither agree nor disagree
4 – Agree
5 – Strongly Agree

13. Food processed using nanotechnology should be labeled with an additional nanotechnology label.

1 – Strongly disagree
2 – Disagree
3 – Neither agree nor disagree

4 – Agree
5 – Strongly Agree

14. Food product labels are currently regulated by the Food and Drug Administration (FDA). What level of trust do you have in the FDA to effectively ensure the safety of food **products** associated with nanotechnology?

1 – Complete distrust
2 – Some distrust
3 – Neither trust nor distrust
4 –Some Trust
5 – Complete trust

15. If nanotechnology food products and food packaged in materials containing nanotechnology are labeled with an additional nanotechnology label, how strongly do you trust the FDA to effectively regulate and enforce the **additional nanotechnology label**?

1 – Complete distrust
2 – Some distrust
3 – neither trust nor distrust
4 –Some Trust
5 – Complete trust

16. Let's assume that adding an additional nanotechnology label increases the product's cost. Who should pay that extra cost?

1 – Consumers
2 – Producers (Makers of the nanofood product in industry)
3 – Government
4 – Consumers & Producers
5 – Consumers & Government
6 – Producers & Government
7 – All three groups
8 – None of them
9—Other _____ (fill in blank)

17. If the cost of the additional nanotechnology label was placed in part or totally on consumers through raising the price of labeled products, what is the **maximum increase you would be willing to pay** for a product to have it labeled with a nanotechnology label, if the initial cost without the nanotechnology label is $5.00?

Starting price without nanotechnology label: **$5.00**

1 – I would not be willing to pay extra for a nanotechnology label
Total Product Price = $5.00

2 – Extra 1% = $0.05
Total Product Price = $5.05

3 – Extra 5% = $0.25
Total Product Price = $5.25

4 – Extra 10% = $0.50
Total Product Price = $5.50

5 – Extra 15% = $0.75
Total Product Price = $5.75

6 – Extra 20% = $1.00
Total Product Price = $6.00

7 – Extra 25% = $1.25
Total Product Price = $6.25

8 – I would be willing to pay **more** than 25% for the nanotechnology label
Total Product Price = greater than $6.25

18. Imagine that nanotechnology product labeling is mandatory in the U.S. and that for all products containing nanomaterials, you have the option of buying the product *without* nanomaterials. If the product containing nanomaterials is $5.00, what is the **maximum increase price you would be willing to pay** for the product *without* nanomaterials?

1 – I would not be willing to pay extra for the product *without* nanomaterials
Total Product Price = $5.00

2 – Extra 1% = $0.05
Total Product Price = $5.05

3 – Extra 5% = $0.25
Total Product Price = $5.25

4 – Extra 10% = $0.50
Total Product Price = $5.50

5 – Extra 15% = $0.75
Total Product Price = $5.75

6 – Extra 20% = $1.00
Total Product Price = $6.00

7 – Extra 25% = $1.25
Total Product Price = $6.25

8 – I would be willing to pay **more** than 25% for the product *without* nanomaterials
Total Product Price = greater than $6.25

19. The following questions are about you so that we can learn how different types of people feel about the topics that are included in this study. **Please respond to the following questions:**

a. What is your age? _____

b. What is the highest educational level you completed?

_____ Less than high school

_____ Some high school

_____ High school (includes GED)

_____ Some college (includes Associate Degree)

_____ College graduate (BS, BA, etc)

_____ Some graduate education.

_____ Graduate degree (MA, MS, PhD, JD, MD, etc.).

c. Are you:

_____ Female

_____ Male

d. Race/ethnicity:

Are you Hispanic or Latino?

_____ Yes

_____ No

Please select one or more races that you identify with from the following:

_____ American Indian or Alaskan Native

_____ Asian

_____ Black or African American

_____ Native Hawaiian or Other Pacific Islander

_____ White

e. Other than for family and community events (i.e. weddings, funerals, etc.) about how often have you attended religious services in the past twelve months?

More than once a week	About once a week	2-3 times a month	About once a month	Less than once a month	Only on special holy days	About once a year	Have not attended

f. Whether you attend religious services or not, would you say you are a very religious person, somewhat religious, not too religious, or not at all religious?

Very Religious	Somewhat religious	Not too religious	Not religious at all

g. How much does religion guide the decisions you make on a daily basis?

Not at all	Not too much	A little	Some	Mostly	A great deal	Completely

h. How much does your religiosity affect how you view issues relating to science and technology?

Not at all	Not too much	A little	Some	Mostly	A great deal	Completely

i. What was your total family income in 2008, before taxes and other deductions were taken out?

Less than $25,000	$25,000 - $50,000	$50,000 - $75,000	$75,000- $100,000	$100,000 - $150,000	More than $150,000

j. The terms "liberal" and "conservative" mean different things to people. Generally speaking, how would you place your views on this scale?

Very liberal	Somewhat liberal	Moderate	Somewhat conservative	Very conservative