



## Ethical orientations of Ohio residents toward genetically engineered plants and animals: An urban/rural comparison

Ted L. Napier\*, Mark A. Tucker, Coreen Henry and Xiaoyan Yang

Department of Human and Community Resource Development; School of Natural Resources and the Environmental Science  
Graduate Program of the Ohio State University, 2120 Fyffe Road, Columbus, Ohio 43210. \*e-mail: napier.2@osu.edu

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### Abstract

Data were collected from 902 adult residents of Ohio during the winter and spring of 2003 to assess ethical orientations toward genetic engineering of plants and animals. Data were collected using a structured questionnaire that was mailed to randomly selected people living within rural and urban areas of the state. A return rate of 52.5% was achieved using three mailings. Ethical orientations toward genetic engineering of plants and animals were assessed using a Likert-type scale that was shown to have a 0.84 coefficient of reliability which is considered good by contemporary social science standards. The theoretical perspective used to guide the investigation was developed from selected components of social learning and risk perception theories. Structural equation modeling was used to examine the merits of the theoretical perspective developed to guide the investigation. Study findings revealed the theoretical model was effective for predicting variability in ethical orientations toward genetically engineered (GE) plants and animals. Approximately 44% of the variance in the dependent variable for the total sample was explained by the statistical model. The structured equation model developed for the total sample was shown to be good for assessing direct and indirect effects of several variables on ethical orientations toward GE plants and animals. All of the significant variables within the model were shown to be consistent with research hypotheses. Findings revealed that perceived risk associated with the production and consumption of GE plants and animals was the best predictor of ethical orientations toward GE products. The data were divided into rural and urban sub-samples and analyzed using structural equation modeling. The structural equation models were shown to be different for rural and urban respondents. Findings are discussed in the context of future acceptance of GE plants and animals among Ohio residents.

**Key words:** Genetic engineering, plants, animals, ethics, rural, urban.

### Introduction

Human manipulation of the cellular structure of plants and animals has contributed significantly to the well-being of human societies for decades. Pharmaceuticals produced via genetic engineering have been widely accepted and acclaimed throughout the world<sup>7,27</sup>. Hundreds of millions of people would have suffered severe physical health problems or would have perished had GE pharmaceuticals not been created. Few people question the positive contributions of pharmaceuticals and vaccines for protecting human and animal health and multitudes of people willingly consume large quantities of these products each year in hopes of preventing or curing a host of diseases.

While a large majority of the world's population have embraced GE pharmaceuticals and vaccines, a significant portion of the world's population has expressed reservations about the creation of agricultural food and fiber products using genetic engineering technologies<sup>3,11,17,19-22,31</sup>. The recently expressed concerns about GE food and fiber products is somewhat surprising because plants and animals have been subject to genetic manipulation since the beginning of recorded history. Selective breeding of plants and animals has been practiced for centuries and the results of those efforts have created better and more plentiful food and fiber products<sup>27</sup>.

Agricultural products derived from selective breeding have been universally hailed as contributing significantly to human well-being. Selective breeding has created highly productive plants and animals that have made it possible for a relatively

small number of agriculturalists to feed, clothe and house large populations not engaged in food and fiber production. Without successful selective breeding of agricultural plants and animals, few of the intellectual and technological advances made by human societies would have been possible.

The acceptance of food and fiber products created by selective breeding strongly suggests the concern about genetic engineering of plants and animals cannot be attributed to fear of GE food and fiber products. A large number of GE products have been in existence for a number of years and have been widely consumed throughout the world. Reservation about GE food and fiber products also cannot be attributed to scientific evidence that such plants and animals produce negative consequences for human populations and the physical environment. Existing scientific evidence strongly suggests that GE plants and animals produce numerous benefits with few negative consequences<sup>1,5,6,9,10,15,28,33-38,44-46</sup>.

Since many GE plants and animals have been widely accepted throughout the world and since scientific evidence strongly indicates that such organisms produce numerous benefits with very few negative consequences, one must question why a significant percentage of people in several societies have expressed concern about the creation of such life forms. One explanation for the expressed concerns is the ethical orientation of human populations regarding genetic engineering of plants and animals. If people strongly believe that human beings do

not have the ethical right to influence the evolution of plants and animals, then the concerns articulated about GE food and fiber products are understandable.

Concern about the ethics associated with human manipulation of the basic genetic structure of plants and animals has been observed<sup>18, 23, 40</sup>. While acknowledging that most people have accepted many human-engineered food and fiber products produced by selective breeding, it has been noted that some people express concern about human beings interfering with the "natural evolution" of plants and animals. People in several societies have expressed concern about a future dominated by human-engineered life forms.

Ethical concerns expressed about human manipulation of the genetic structure of plants and animals cannot be ignored because public policies are influenced by perceptions and opinions of societal members. Research and development required to create new life forms must be legitimized by society. Opposition to genetic engineering research and development could result in the formation of public policies that effectively prohibit creation of GE plants and animals. Such policy actions could make it more difficult to feed, clothe and house the billions of people expected to populate this planet in the future.

The purpose of this paper is to discuss the findings of a study organized to assess ethical orientations of Ohio residents toward genetic engineering of plants and animals. The findings are discussed in the context of future acceptance of genetic engineering of plants and animals among populations similar to the study sample.

### Theoretical Modeling

The theoretical perspective used to guide the investigation was developed from selected components of social learning theory<sup>2, 8, 24-26</sup> and risk perception theory<sup>39, 27, 41-43</sup>. The contribution of each theory is outlined below.

Social learning theory basically argues that ethical orientations are a product of direct and indirect learning experiences. The theory posits that learning experiences occur when individuals have direct contact with various components of their physical and social worlds. The model also recognizes that human beings can learn about many components of their physical and social worlds indirectly by observing others and by accessing verbal and print communication channels.

Social learning theory argues that human beings are exposed to a multitude of learning opportunities throughout their lives and each learning experience contributes to how individuals perceive and define various components of their physical and social worlds. Perceptions and definitions of all phenomena are strongly influenced by the impact each phenomenon has on the individual and his/her significant others. If a specific phenomenon contributes to the well-being of an individual, then positive perceptions and definitions about the phenomenon being assessed tend to be internalized. Conversely, negative experiences contribute to the formation of negative perceptions and definitions.

Social learning theory posits that individuals learn via direct contact with learning situations. From birth, every individual is influenced by parents, siblings, friends and a host of casual acquaintances. During the course of interaction with other

people and with the physical environment, individuals learn what produces positive outcomes for themselves and significant others and what does not. Future interactions with people and contact with the physical environment are strongly influenced by the formation of perceptions and definitions that emerge as a result of direct contact with various components of an individual's physical and social worlds.

Social learning theory argues that individuals also learn via indirect contact with other people by means of vicarious learning and verbal and written communications. Individuals are frequently exposed to concepts and ideas from printed and electronic media and the information received influences values and perceptions internalized by individuals exposed to such learning experiences.

Ethical orientations are critical components of an individual's value system and are formulated early in one's existence. Ethical orientations are constantly being reinforced by significant others and by other members of society. Every individual receives instruction in what is defined as being socially acceptable and what is unacceptable. Once ethics are internalized by the individual, they are resistant to modification. Ethical orientations serve as moral guides and strongly influence how various elements of a person's physical and social worlds are perceived and defined. Ethics affect behaviors because individuals seek to enact behaviors that are congruent with their ethical orientations.

In the context of ethical orientations toward GE plants and animals, social learning theory posits that life experiences influence how an individual will perceive and define such life forms. It is hypothesized that variables assessing various types of learning experiences will be significantly related with ethical orientation toward genetic engineering of plants and animals. It is expected that exposure to more extensive learning experiences will contribute to better understanding of GE plants and animals which should produce more positive ethical orientations toward such life forms.

Risk perception theory basically argues that attitudes toward a specific phenomenon are strongly influenced by the level of perceived risk posed by the phenomenon being assessed. Learning experiences provide individuals with information needed to assess level of risk associated with various components of their physical and social worlds. Such information is useful for individuals to evaluate a specific phenomenon and to determine how the specific phenomenon will impact the individual and significant others. If a specific phenomenon is perceived as introducing unacceptable levels of risk into an individual's life or into the lives of significant others, then the phenomenon will be evaluated negatively. As the level of perceived risk associated with a specific phenomenon increases, negative ethical orientations toward the phenomenon concomitantly increase.

In the context of ethical orientations toward genetic engineering of plants and animals, risk perception theory suggests that level of perceived risk associated with GE plants and animals will influence how creation of such life forms will be perceived and assessed. It is hypothesized that level of perceived risk associated with production and consumption of GE plants and animals will be significantly related with ethical orientations toward GE plants and animals.

Given the importance of perceived risk in social learning theory and risk perception theory, it was hypothesized that perceived risk would act as an intervening variable between ethical orientation toward GE plants and animals and the other predictive variables included in the model. It was expected that the other predictive factors included in the statistical model would influence ethical orientations toward GE plants and animals directly and that they would also influence the dependent variable indirectly through risk perception.

### Methods

**Sample selection:** Data were collected from 902 adult residents of rural and urban households in Ohio during the winter and spring of 2003. The urban sample was drawn using a systematic random sampling procedure that involved selecting the first name and address on each page of the Columbus, Ohio, residential telephone directory. The rural sample was drawn using a systematic random sampling procedure from the membership list of the Ohio Farm Bureau Federation (OFBF) which is argued to contain the names and addresses of approximately 80 percent of all agriculturalists in the state. Only individuals who indicated on their OFBF membership form that they were engaged in some type of production agriculture were included in the sampling frame. A total of 1,365 urban subjects and 1,086 rural subjects were selected to participate in the study.

A structured questionnaire was mailed to each of the individuals selected to participate in the study with a letter explaining the purpose of the research. A stamped, addressed envelope was included with the questionnaire in which respondents were instructed to return completed questionnaires. Three weeks later a reminder letter, another questionnaire and a stamped return envelope were mailed to non-respondents. A third mailing was posted to non-respondents approximately three weeks after the second wave of questionnaires were mailed. Questionnaires from 1,276 of the original sample were returned using this data collection technique which constitutes a rate of 52.5 percent. Of the questionnaires returned, 902 were sufficiently completed for use in statistical modeling.

**Questionnaire construction:** A structured questionnaire was developed to collect data from study respondents. Data were collected about ethical orientations toward genetically engineered plants and animals, attitudes toward risk associated with the production and consumption of GM plants and animals, socio-demographic characteristics of respondents, perceptions about information channels, and sources used to access information about GM plants and animals. Variables were measured in the following manner:

**Dependent variable:** *Ethical orientation toward genetic engineering of plants and animals* was designated as the dependent variable for this study and was measured using six Likert-type<sup>14, 29</sup> scale items. Possible responses ranged from strongly agree to strongly disagree and were weighted 1 through 5. The range of possible scale scores is from 6 to 30 with higher scores representing more negative orientations toward genetic engineering of plants and animals. Concepts assessed by the scale items are as follows: ethical right of humans to modify the genetic structure of plants and animals, and the ethical right to

insert human genes into the genetic structure of plants and animals. Item analysis of responses to the scale items produced an alpha coefficient of reliability<sup>12</sup> of 0.84. An alpha coefficient of this magnitude indicates the responses to the scale items are highly correlated and that the weighting values can be legitimately summed to form a composite scale score for statistical modeling.

**Predictive variables:** Nine variables were selected to represent components of the social learning-risk perception model developed to guide the investigation. The predictive variables chosen for examination are as follows: level of perceived risk associated with the production and consumption of GE plants and animals, importance of information channels, trust in information sources, awareness of consumption of GE food products, age, education, gender, children living at home, and family engaged in farming. The predictive variables were measured in the following manner:

*Perceived risk* was measured using nine outcomes frequently associated with GE agricultural plants and animals. Respondents were asked to circle numbers along continua with responses ranging from 0 (no risk) to 10 (high risk). The range of possible scale scores is 0 to 90 with higher scale scores representing higher levels of perceived risk. Concepts assessed by scale items are as follows: human health, animal health, environmental impacts, economic impacts, impacts on insects, and impacts on weeds. Item analysis produced an alpha coefficient of reliability of 0.96 which means the responses to the scale items are highly correlated and that the weighting values can be legitimately summed to form a composite scale score.

*Importance of information channels* was measured by asking respondents to assess the importance of four printed and electronic channels for accessing information about GE plants and animals. Respondents selected numbers along continua with responses ranging from 0 (no importance) to 10 (high importance). The range of possible scale scores is 0 to 40 with higher scale scores representing higher levels of importance. The information channels assessed are as follows: television news reports, radio, magazines, and newspapers. Item analysis produced an alpha coefficient of reliability of 0.90 which means the responses to the scale items are highly correlated and that the weighting values can be legitimately summed to form a composite scale score.

*Trust in information sources* was measured by asking respondents to report their level of trust in five sources of information about GE plants and animals. Respondents selected numbers along continua with responses ranging from 0 (no trust) to 9 (high trust). The range of possible scale scores is 0 to 45 with higher scale scores representing higher levels of trust. The sources assessed are as follows: university researchers, corporations engaged in the production of GE products, US Department of Agriculture, Ohio State University Extension, and the US Food and Drug Administration. Item analysis produced an alpha coefficient of reliability of 0.87 which means the responses to the scale items are highly correlated and that the weighting values can be legitimately summed to form a composite scale score.

*Education* was measured as the highest year of formal education completed by the respondent. *Age* was measured as

**Table 1.** Characteristics of study respondents by farming status.

Characteristic		Descriptive data		
		Total sample N = 902	Urban sample N = 507	Rural sample N = 395
Age	Mean	54.0	54.1	53.9
	S.D.	14.7	15.1	14.2
Education	Mean	14.5	15.0	13.7
	S.D.	2.9	3.0	2.6
Gender	Male	72.7%	60.4%	88.6%
	Female	27.3%	39.6%	11.4%
No. of children under 18 living at home	Mean	0.6	0.5	0.7
	S.D.	1.0	1.0	1.1
Family member has consumed	Yes	21.1%	12.8%	31.6%
	No	4.8%	5.9%	3.3%
GMO food products	Do not know	74.2%	81.3%	65.1%
Nonfarm income				
	Less than \$20,000	16.2%	9.1%	25.8%
	20,001 - 30,000	12.8%	11.6%	13.9%
	30,001 - 40,000	10.3%	10.3%	10.9%
	40,001 - 50,000	11.6%	12.8%	10.1%
	50,001 - 60,000	8.5%	8.7%	8.1%
	60,001 - 70,000	6.9%	7.7%	6.1%
	70,001 - 80,000	6.3%	7.9%	4.1%
	80,001 - 90,000	3.1%	2.6%	3.8%
	90,001 - 100,000	4.7%	7.1%	1.8%
	100,001 - 110,000	3.7%	4.5%	2.5%
	110,001 - 120,000	2.4%	3.0%	1.5%
	More than 120,000	7.3%	9.1%	4.8%
	Missing data	6.2%	5.7%	6.6%
Engaged in Farming	Yes =	43.7%		
	No =	56.3%		

the age of the respondent in years at last birthday. *Farming status* was measured by asking respondents if any member of their household operate a farm. A positive response received a value of 0 and a negative response received a value of 1. *Gender* was assessed by asking respondents to indicate their gender. Males received a value of 0 and females received a value of 1. *Children* was measured as the number of children under 18 years of age who were living at home at the time of the data collection. *Awareness of GE food consumption* was measured by asking respondents to indicate if any member of their household had consumed food products containing GE material. A positive response received a value of 0 and negative/uncertain responses received a value of 1.

**Statistical analysis:** Descriptive statistics were used to explore general trends within the data set while structural equation modeling<sup>4, 30, 32</sup> was employed to assess the merits of the theoretical model used to guide the investigation. Missing data were assigned the variable mean<sup>13</sup> which has been shown to be

<sup>13</sup> While data were collected for both farm and nonfarm family income, it was decided that use of both measures would introduce interactive effects and obscure the relationships of both variables. Practically all of the rural respondents reported nonfarm income, while practically none of the urban respondents reported farm income. Therefore, only nonfarm income was used in the statistical modeling to represent family income. To test the validity of this approach, both farm income and nonfarm income were summed to form a composite measure called "total family income" and it was used in the statistical modeling to determine if the selection of nonfarm income introduced systematic error. The findings for the total family income measure and the nonfarm income measure were the same.

<sup>2\*</sup> It is highly probable that every person within the sample has consumed food products containing GM material. The low percentage who indicated they were knowledgeable of consumption of GM products indicates that the majority of respondents in both samples are not well informed about genetically engineered food products.

the best methodology for salvaging cases when the sample size is large, the percentage of missing data is small, and the correlations among the variables are low to moderate. All of these conditions were satisfied within the data set.

## Results and Discussion

**Descriptive findings:** The characteristics of the total study sample and for the urban and the rural subgroups are presented in Table 1. The findings show that study respondents were middle-aged people who are relatively well educated with nonfarm income<sup>1\*</sup> below \$50,001. Relatively few children below the age of 18 remained in respondent households. A large percentage of respondents were male and about 44% of the total sample reported a family member being engaged in farming. A minority of respondents indicated awareness that members of their household have consumed food products containing GE materials.<sup>2\*</sup> A much larger percentage of rural respondents reported awareness of GE food consumption than did urban respondents. Descriptive findings for ethical orientations toward genetic engineering of plants and animals are presented in Table 2 and reveal considerable variability in terms of the issues assessed. The computed mean scale score of 18.7 indicates that respondents as a total group were in the neither agree nor disagree category relative to ethical orientations toward genetic engineering of plants and animals. However, there are major differences in terms of how genetic engineering of plants and animals are perceived. While respondents tended to believe that human beings have the ethical right to manipulate the genetic structure of plants, they tended to believe that genetic

structure of animals should not be manipulated. The total study group did not perceive insertion of human genes into the genetic structure of plants or animals to be ethical. Findings for the urban and rural samples consistently revealed that rural respondents perceived genetic engineering of plants and animals to be more ethical than urban respondents for all of the issues assessed in the study.

Descriptive findings for perceived level of risk associated with the production and consumption of GE plants and animals are presented in Table 3. The mean scale score for the total sample is 44.6 which indicates that respondents as a group tended to perceive some risk associated with the production and consumption of GE plants and animals. The highest ranked risks were the creation of pesticide resistant weeds and resistant insects followed closely by destruction of beneficial insects and loss of global markets for US farm products. The two issues considered to be at the least risk were loss of agricultural productivity and environmental damage. The findings for the urban and rural samples consistently revealed that urban respondents perceived higher levels of risk associated with the production and consumption of GE plants and animals than did rural respondents for all of the possible outcomes assessed.

Descriptive findings for the level of trust placed in institutional sources of information about GE plants and animals are presented in Table 4. The mean scale score for the total sample was 24.6 which indicates respondents exhibit *some trust* in the sources assessed. Findings show that respondents place considerable trust in university sources. The least trusted source of information about GE plants and animals was corporations engaged in the production of such life forms. Federal agencies were somewhat trusted as sources of information about GE plants and animals. Findings for the urban and rural subgroups revealed that the rural sample exhibited higher levels of trust of information sources than did the urban sample. The only exception was for the US Food and Drug Administration in which the urban sample expressed more trust than did rural respondents.

Descriptive findings for the level of importance of mass media channels for accessing information about GE plants and animals are presented in Table 5. All of the channels assessed were perceived to be *somewhat important* with a mean scale score of 19.2 for the total sample. The most important channel for accessing information about GE plants and animals was magazines followed closely by newspapers. The least important channels were television news and radio even though the mean values for these two channels indicate they were somewhat important to respondents. Findings for the urban and rural groups revealed that newspapers, television news, and radio were perceived to be more important channels for urban respondents than for the rural study group. Rural respondents reported that magazines were more important channels for accessing information about GE plants and animals than did urban study participants.

**Multi-variate findings:** Structural equation modeling<sup>4,30,32</sup> was employed to examine the merits of the theoretical model used to guide the investigation. Structural equation modeling is a statistical technique that permits researchers to model both direct and indirect effects of research variables which provides a much more comprehensive assessment of the merits of a system of theoretical hypotheses. The findings for the total sample are

**Table 2.** Ethical orientation toward genetically engineered plants and animals presented in percentages (N=902).

Statement	Possible response					S.D.	
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree		
It is ethically unacceptable to# insert human genes into animals	T	32.9	25.1	21.7	13.0	7.3	3.6
	U	34.9	26.2	18.7	14.0	6.1	3.7
It is ethically unacceptable to# insert human genes into plants	R	30.1	23.5	25.8	11.6	8.9	3.5
	T	27.7	26.4	24.6	13.5	7.8	3.5
It is ethically acceptable to+ genetically modify animals	U	30.6	26.0	21.5	15.0	6.9	3.6
	R	24.1	26.8	28.6	11.6	8.9	3.5
Human beings do not have the# right to modify the basic genetic structure of animals	T	9.0	21.5	21.8	26.6	21.1	3.3
	U	7.5	20.9	19.9	28.4	23.3	3.4
It is ethically acceptable to+ genetically modify plants.	R	10.9	22.3	24.3	24.3	18.2	3.2
	T	19.7	27.3	20.8	22.1	10.1	3.3
Human beings have the right+ to modify the basic genetic structure of plants.	U	9.7	22.7	16.6	30.2	20.9	3.3
	R	10.6	21.3	26.3	23.5	18.2	3.2
Human beings have the right+ to modify the basic genetic structure of plants.	T	17.1	41.0	18.1	13.5	10.3	2.6
	U	12.8	40.4	18.9	17.0	10.8	2.7
Human beings have the right+ to modify the basic genetic structure of plants.	R	22.5	41.8	17.0	9.1	9.6	2.4
	T	14.7	40.2	22.8	12.9	9.3	2.6
Human beings have the right+ to modify the basic genetic structure of plants.	U	11.2	36.9	24.5	16.8	10.7	2.8
	R	19.2	44.6	20.8	7.8	7.6	2.4
Alpha for scale = 0.84					Scale mean = 18.7		

\* Percentages may not sum to 100.0 due to rounding error.  
 + Responses weighted 1 to 5 with "strongly agree" receiving a 5,  
 # Responses weighted 5 to 1 with "strongly agree" receiving a 5 and "strongly disagree" receiving a 1.  
 T = total sample; U = urban sample; R = rural sample.

**Table 3.** Perceived level of risk associated with production and consumption of genetically engineered plants and animals presented in percentages (N = 902)\*.

Possible outcome	Level of Risk										MD	X̄	SD		
	No Risk 0	1	2	3	4	5	6	7	8	9				High Risk 10	
Creation of pesticide-resistant weeds	T	3.2	4.3	6.0	7.1	8.3	18.1	9.7	10.0	11.1	5.2	14.1	2.9	5.8	2.8
Creation of pesticide-resistant insects	R	3.5	5.3	6.6	8.6	9.1	17.2	9.9	10.9	10.1	2.5	13.9	2.3	5.6	2.8
Destruction of Beneficial insects	T	4.1	6.3	8.9	9.1	9.9	19.0	11.1	10.6	7.6	2.0	11.4	0.0	5.2	2.8
Loss of global markets for US agricultural products	R	3.4	3.4	5.9	8.7	8.3	20.3	8.7	8.3	11.0	6.7	15.2	0.2	5.9	2.8
Harm to wildlife	T	3.8	1.5	9.1	7.3	9.9	20.0	9.1	8.1	9.9	3.5	15.7	2.0	5.7	2.8
Human health problems	R	14.9	13.4	15.2	9.1	7.8	11.9	5.1	3.8	3.0	3.3	10.6	1.8	3.9	3.2
Animal health problems	T	8.5	6.8	14.2	11.8	7.7	16.8	5.4	6.4	6.7	3.2	10.1	2.4	4.6	3.0
Environmental damage	R	14.2	9.9	19.2	12.4	6.6	13.7	3.8	3.8	4.3	1.8	8.9	1.5	3.8	3.0
Loss of agricultural productivity	T	7.3	5.5	13.8	14.4	8.3	17.9	5.7	6.7	6.1	2.6	8.1	3.6	4.1	2.9
	R	14.7	14.7	17.5	13.4	5.6	11.1	3.5	2.5	4.6	2.0	8.6	1.8	3.6	3.0
Alpha for scale = 0.96 Scale mean = 44.6 S.D. = 22.8															

\* Percentages may not sum to 100.0 due to rounding error. MD = missing data. X̄ = mean. SD = standard deviation. T = total sample; U = urban sample; R = rural sample.

**Table 4.** Level of trust placed in institutional sources of information about genetically engineered plants and animals presented in percentages (N = 902)\*.

Source assessed	Level of Trust										MD	X̄	SD		
	No Trust 0	1	2	3	4	5	6	7	8	9				High Trust	
Ohio State University Extension	T	2.3	2.2	3.2	4.9	11.8	16.1	14.3	19.1	13.7	10.8	1.1	5.9	2.2	
University researchers	R	4.9	3.4	6.1	9.3	18.1	18.5	13.0	12.6	6.9	6.1	1.1	5.7	2.1	
US Department of Agriculture	T	2.4	1.7	3.9	5.1	11.1	18.6	14.7	20.7	10.6	10.1	1.0	5.8	2.1	
US Food and Drug Administration	R	2.2	1.8	3.6	5.7	12.8	18.9	15.0	19.7	8.9	10.1	0.4	5.7	2.1	
Corporations engaged in the production of GMOs	T	2.8	1.5	4.3	4.3	8.9	18.2	14.4	22.0	12.9	10.1	0.5	5.9	2.2	
	R	4.7	2.9	5.5	7.4	16.5	18.8	13.5	14.5	8.1	7.2	0.8	5.1	2.3	
	T	4.9	3.4	6.1	9.3	18.1	18.5	13.0	12.6	6.9	6.1	1.0	4.9	2.3	
	R	4.3	2.3	4.8	5.1	14.4	19.2	14.2	17.0	9.6	8.6	0.5	5.4	2.3	
	T	6.2	3.2	8.6	8.3	15.4	18.8	13.3	12.9	6.7	5.8	0.8	4.8	2.3	
	R	5.9	3.2	8.3	8.5	15.2	17.9	12.6	14.0	8.1	5.5	0.8	4.9	2.3	
	T	6.6	3.3	9.1	8.1	15.7	20.0	14.2	11.4	4.8	6.1	0.8	4.7	2.3	
	R	16.5	9.1	20.6	14.6	13.4	13.2	4.9	5.1	1.4	1.1	0.0	3.0	2.2	
	T	18.7	11.2	23.1	15.4	12.4	10.8	3.9	3.0	1.0	0.4	0.0	2.6	2.0	
	R	13.7	6.3	17.5	13.7	14.7	16.2	6.1	7.8	2.0	2.0	0.0	3.5	2.3	
Alpha for scale = 0.87 Scale mean = 24.6 S.D. = 8.9															

\* Percentages may not sum to 100.0 due to rounding error. MD = missing data. X̄ = mean. SD = standard deviation. T = total sample; U = urban sample; R = rural sample.

**Table 5.** Perceived level of importance of selected media channels to access information about genetically engineered plants and animals presented in percentages (N = 902)\*.

Channel assessed	Perceived Importance										X	S.D.			
	No Importance 0	1	2	Slight Importance 3	4	5	6	7	8	9			10	MD	
Magazines	T	4.3	3.7	7.8	8.1	12.1	19.8	11.4	12.6	10.4	3.5	4.1	2.1	5.2	2.4
	U	3.7	4.3	6.9	7.9	15.0	20.3	11.4	12.0	9.1	3.4	3.7	2.2	5.1	2.4
Newspapers	R	5.1	2.8	8.9	8.4	8.4	19.2	11.4	13.4	12.2	3.8	4.6	2.0	5.3	2.5
	T	5.5	5.3	8.1	8.3	11.2	17.5	10.9	10.6	10.4	4.7	5.5	1.9	5.1	2.6
Television news	U	3.6	4.7	6.7	7.9	12.8	17.6	10.3	12.4	10.5	4.9	6.7	2.0	5.4	2.6
	R	8.1	6.1	9.9	8.9	9.1	17.5	11.6	8.4	10.4	4.3	4.1	1.8	4.8	2.7
Radio	T	10.3	7.4	11.2	9.8	8.6	17.0	7.5	10.1	7.6	3.7	5.7	1.8	4.5	2.8
	U	6.9	5.3	9.1	11.0	9.7	17.9	7.1	10.8	9.5	3.0	6.9	2.0	4.9	2.8
Radio	R	14.7	10.1	13.9	8.1	7.3	15.7	8.1	9.1	5.3	2.0	4.1	1.5	3.9	2.8
	T	7.5	7.3	10.3	10.8	12.6	19.1	7.1	8.1	7.5	3.4	4.2	2.0	4.5	2.6
Radio	U	6.9	5.3	9.1	11.0	9.7	17.9	7.1	10.8	9.5	3.7	6.9	2.0	4.8	2.6
	R	11.4	8.6	12.7	7.6	12.2	18.7	7.3	7.3	6.6	2.5	3.3	1.8	4.1	2.7
Alpha for scale = 0.90											Scale mean = 19.2 S.D. = 9.3				

\* Percentages may not sum to 100.0 due to rounding error. MD = missing data. X = mean. S.D. = standard deviation. T = total sample; U = urban sample; R = rural sample

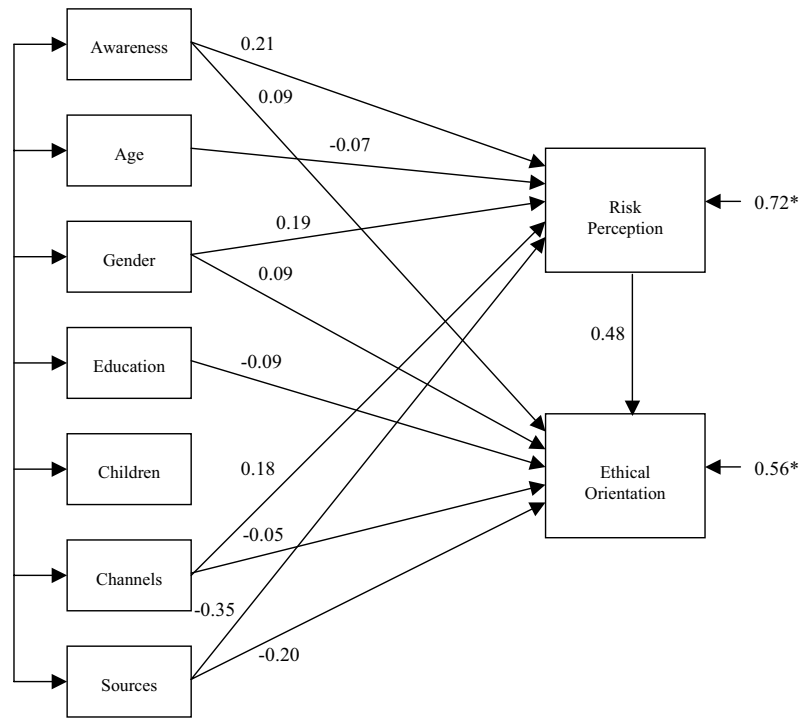
presented in Fig. 1.

The structural equation model for the total sample is presented in Fig. 1 and reveals that six variables are directly and significantly related to ethical orientations toward genetically engineering of plants and animals at the 0.05 level. The error term for the ethical orientation component of Fig. 1 is 0.56 which indicates that 44 percent of the variance in ethical orientation scores is explained by the six significant predictive variables. The six significant variables are as follows: perceived risk associated with production and consumption of GE plants and animals, awareness of consumption of GE food products, gender, education, importance of information channels, and trust in information sources. Respondents who expressed more negative ethical orientations toward genetic engineering of plants and animals tended to exhibit the following characteristics: perceived higher levels of risk associated with production and consumption of GE plants and animals, lacked awareness of consumption of GE food products, were female, reported lower educational attainment, placed lower levels of importance on information channels, and placed less trust in information sources. All of these relationships are consistent with the theoretical model used to guide the investigation. The best predictor of the variability in ethical orientation of respondents was level of perceived risk which explained most of the variance in the model.

The findings presented in Fig. 1 also show that several predictive variables influenced ethical orientations toward genetic engineering of plants and animals *indirectly* via risk perception. Five predictive variables were shown to be directly and significantly related with risk perception at the 0.05 level. The error factor for the risk perception equation is 0.72 which means that 28 percent of the variance in risk perception scores was explained by the five significant variables. The significant variables are as follows: awareness of consumption of GE food products, age, gender, importance of information channels, and trust in information sources. Respondents who perceived higher levels of risk associated with production and consumption of GE plants and animals tended to exhibit the following characteristics: lacked awareness of past consumption of GE food products, were female, were younger, placed more importance on information channels, and placed less trust in information sources. These findings were consistent with the theoretical model except for age and trust in information channels. It was expected that older individuals and those who placed lower importance on information channels would perceive greater risk associated with production and consumption of GE plants and animals, however, the opposite was observed.

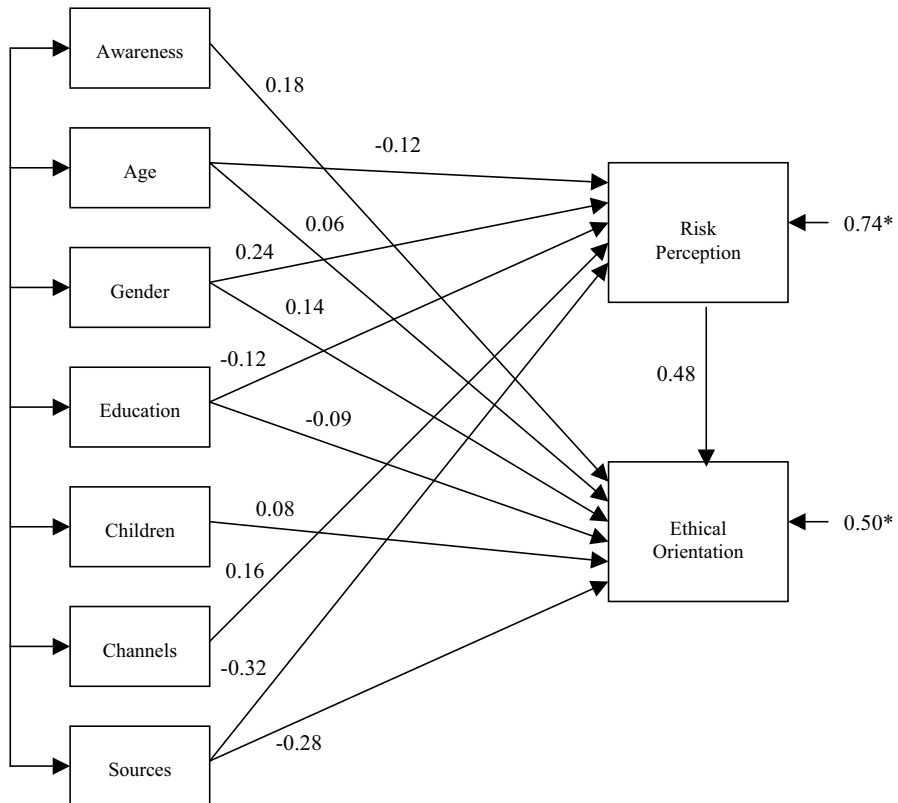
While the findings presented in Fig. 1 basically validated the theoretical modeling and provided insight to ethical orientations toward genetic engineering of plants and animals among study respondents, additional statistical analyses were conducted on the data. Since descriptive findings revealed substantial differences between rural and urban respondents it was deemed important to explore potential differences between the two study groups.

In addition to the statistical justification for exploring differences between urban and rural subgroups, there was also theoretical justification for doing so. Since farmers have been engaged in the production of GE food and fiber products for a number of years, it was expected that agriculturalists would



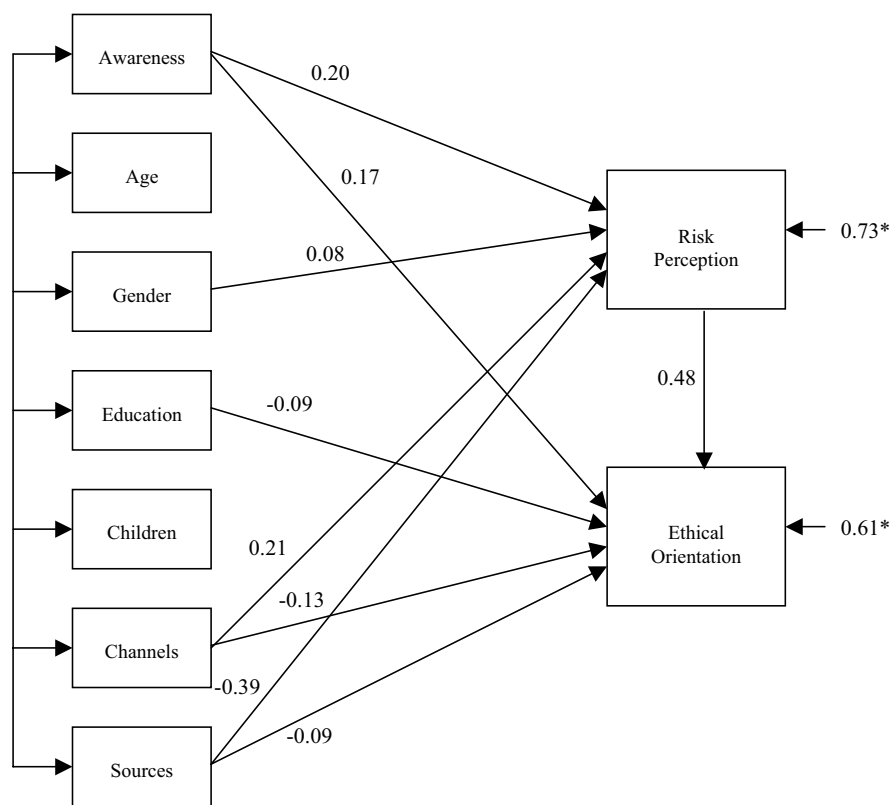
Chi-Square=4.63, df=25, P-value=1.000, RMSEA=0.00 All beta coefficients are significant beyond the 0.05 level.  
 \* Unexplained variance

**Figure 1.** Structural equation model for total sample: Selected predictive factors and ethical orientation (N = 902).



Chi-Square=5.01, df=24, P-value=0.999, RMSEA=0.00 All beta coefficients are significant beyond the 0.05 level.  
 \* Unexplained variance

**Figure 2.** Structural equation model for urban respondents: Selected predictive factors and ethical orientation (N = 507).



Chi-Square=15.72, df=27, P-value=0.958, RMSEA=0.00  
 \* Unexplained variance

All beta coefficients are significant beyond the 0.05 level.

Figure 3. Structural equation model for rural respondents: Selected predictive factors and ethical orientation (N = 395).

possess greater knowledge of GE food and fiber products. Since the social learning/risk perception model used to guide the investigation suggests that experience is one of the most important factors in the formation of ethical orientations, it was expected that findings for rural respondents would differ from those of urban respondents. To assess the validity of these statistical and theoretical justifications, the data for study respondents were divided on the basis of farming status to produce rural and urban study groups. Structural equation modeling identical to that conducted on the total sample was done for each subgroup.

The structural equation model for the urban sub-sample is presented in Fig. 2 and reveals that seven variables are directly and significantly related to ethical orientations toward genetic engineering of plants and animals at the 0.05 level. The error term for ethical orientation scale scores is 0.50 which indicates that 50 percent of the variance was explained by the seven significant predictive variables. The significant predictive factors are as follows: risk perception, awareness of consumption of GE food products, age, gender, education, number of children living at home, and trust in information sources. Urban respondents who expressed more negative ethical orientations toward genetic engineering of plants and animals tended to exhibit the following characteristics: perceived higher levels of risk associated with

production and consumption of GE plants and animals, lacked awareness of consumption of GE food products, were female, were older, reported lower educational attainment, reported more children living at home, and placed less trust in information sources. The risk perception variable explained most of the variance in the model. All of the significant relationships are consistent with the theoretical model used to guide the investigation. The amount of explained variance was slightly higher for the urban sub-sample than for the total sample and age entered the model. Otherwise the findings are similar to the findings for the total sample.

The findings for risk perception presented in Fig. 2 revealed that five variables were significantly related to perceived risk which means that the five variables influenced ethical orientations toward genetically engineered plants and animals indirectly via risk perception. The error term is 0.74 which means the five significant variables explained 26 percent of the variance in risk perception scale scores. The five significant variables are as follows: age, gender, education, importance of information channels, and trust in information sources. Respondents who perceived higher levels of risk associated with production and consumption of GE plants and animals exhibited the following characteristics: younger, female, reported lower educational attainment, placed more importance on information channels, and placed less trust in information sources. These findings were consistent with the theoretical model except for age and information channels. It was expected that older individuals and those who placed lower importance on information channels

<sup>39</sup> P values vary from 0.0 to 1.0 with values closer to 1.0 indicating better fit of the model to the data. The Figure 1 P-value is 1.0 which indicates a perfect fit of the model to the data. The urban P-value was 0.999 which is almost a perfect fit. The P-value of 0.958 for the rural model is very high and indicates a very good fit of the model to the data.

would perceive greater risk associated with production and consumption of GE plants and animals, however, the opposite was observed.

The structural equation model for the rural sub-sample is presented in Fig. 3 and reveals that five variables are directly and significantly related to ethical orientation scale scores at the 0.05 level. The error term for the ethical orientation scale scores is 0.61 which means that 39 percent of the variance in ethical orientation scores was explained by the five significant predictive variables.

The predictive variables shown to be significant in Fig. 3 are as follows: risk perception, awareness of consumption of GE food products, education, importance of information channels and trust in information sources. Respondents who expressed more negative ethical orientations toward genetic engineering of plants and animals tended to exhibit the following characteristics: perceived higher levels of risk associated with GE plants and animals, lacked awareness of consumption of GE food products, reported lower educational attainment, placed lower importance on information channels, and placed less trust in information sources. The best predictor of the variability in ethical orientation of respondents was level of perceived risk. The risk variable explained most of the variance in the model. All of the relationships shown to be significant at the 0.05 level are consistent with the theoretical model used to guide the investigation.

The findings for risk perception presented in Fig. 3 revealed that four variables are significantly related to perceived risk associated with production and consumption of GE plants and animals. This finding means the four significant variables influence ethical orientations *indirectly* via risk perception. The four significant variables are as follows: awareness of consumption of GE food products, gender, importance of information channels, and trust in information sources. The error term is 0.73 which means that 27 percent of the variance in risk perceptions was explained by the four significant variables. Respondents who perceived higher levels of risk associated with production and consumption of GE plants and animals tended to exhibit the following characteristics: lacked awareness of past consumption of GE food products, were female, placed more importance on information channels, and placed less trust in information sources. These relationships are consistent with the theoretical model except the finding for importance of information channels. It was expected that individuals who reported lower levels of importance would exhibit higher perceived risk, however, the opposite was observed. The other significant relationships were consistent with research hypotheses.

The findings for the rural sub-sample indicate that the findings are similar to findings for the total sample and for the urban group. The amount of explained variance was much higher for the urban group which is consistent with research expectations. This finding indicates the theoretical model functioned better for the urban portion of the sample. This is probably due to rural farm people being more knowledgeable of genetically engineered food and fiber products.

The tests<sup>3</sup> for “goodness of fit” of the models presented in Figs 1-3 reveal that all three models are almost perfect fits with the data. These findings indicate the theory has significant

merit for understanding the relationships among the study variables.

### Conclusions

Study findings revealed that respondents perceived genetic engineering of animals to be somewhat unethical, however, they perceived genetic manipulation of plants to be somewhat ethical. These findings strongly suggest that considerable uncertainty exists about the ethics associated with genetic engineering of animals. The highest level of ethical concern was expressed about the insertion of human genes into plants and animals. The policy implication of these findings is that public scrutiny will probably be focused on the manipulation of animals and the use of human genes in genetic research.

Findings for perceived level of risk associated with the creation of GE plants and animals revealed that respondents believed that GE plants and animals posed somewhat of a risk to all of the possible outcomes assessed in the study. While scientific research has demonstrated few negative consequences associated with GE plants and animals, study respondents apparently are not aware of the findings or do not believe the findings are valid. The policy implications of these findings is that public policy regarding GE plants and animals may be influenced by incorrect perceptions of the risk level associated with the production and consumption of genetically engineered plants and animals.

Findings for level of trust placed in institutional sources of information about GE plants and animals revealed that the highest level of trust resided in university sources. Relative little trust was placed in commercial producers of GE plants and animals. Respondents apparently believe that corporations have a vested interest in the production of GE products and cannot be objective in the generation and dissemination of information about their products. The policy implication of these findings is that university faculties should assume the primary research role of assessing the socioeconomic and environmental consequences of GE plants and animals. Members of society should be more responsive to study findings produced by university faculties than other sources of scientific information.

Findings for level of importance of mass media channels for accessing information about GE plants and animals revealed that all of the channels assessed were somewhat important. There was no channel consistently chosen as the most important source of information about GE plants and animals. The policy implication is that information about GE plants and animals should be disseminated via numerous mass media channels. Producers of scientific information about GE plants and animals should be strongly encouraged to publish their study findings in mass media channels in addition to professional journals which are not read by the general public.

Structural equation modeling revealed the theoretical model had considerable utility for predicting ethical orientations of respondents toward genetic engineering of plants and animals. The most important predictive factor was perceived level of risk associated with the production and consumption of GE plants and animals. As the level of perceived risk increased there was a concomitant increase in the perception that genetic manipulation of plants and animals was not ethical. Perceived

risk was shown to be the most important predictive variable for all of the structural equation models developed. The risk perception findings observed in the structural equation models are very important because respondents tended to perceive some level of risk associated with production and consumption of GE plants and animals. The concern expressed by respondents about the level of risk posed by GE products is not consistent with scientific evidence that demonstrates GE products do not pose a risk to the environment or to human or animal health. This finding strongly suggests a need for education of the public about the risks posed by GE food and fiber products.

The conclusion derived from the risk finding is confirmed by the information/awareness variables. As level of trust increased in information sources, as the perceived importance of multiple channels of information increased, and as awareness that family members had consumed GE food products increased, respondents tended to perceive genetic engineering of plants and animals to be more ethical. These findings indicate that exposure to information about GE plants and animals affects ethical orientations toward such products. The findings also suggest that sources and channels of information can be effectively employed to reduce perceptions of risk and fear of GE products. These findings suggest that trusted information systems should be employed to disseminate scientific evidence about GE food and fiber products. The awareness finding reveals that when people are aware that GE food products have been consumed by family members with no adverse consequences, ethical orientations toward genetic engineering of plants and animals are influenced in a positive manner. Use of information sources to demonstrate that most people in the United States have consumed GE food products with no adverse consequences may serve to reduce concern about genetic engineering of plants and animals.

Gender findings revealed that males perceived genetic engineering of plants and animals to be more ethical than females. This finding may be the result of misinformation provided to females about the level of risk posed by GE food products. The provision of scientific information that demonstrates GE plants and animals do not pose a risk to the environment or human/animal health may serve to change the ethical orientations of females toward GE products.

Lastly, information about GE food and fiber products needs to be directed toward less educated people. More highly educated people apparently were more aware of the net benefits associated with the production and consumption of GE food and fiber products because they tended to perceive creation of such products as being more ethical.

In summary, the study findings strongly suggest a need for the dissemination of scientific evidence to the public about GE plants and animals. Exposure to existing scientific research which demonstrates that GE plants and animals contribute many net benefits to the well-being of humans and animals should reduce the level of perceived risk. Reduction of perceived level of risk should result in an increase in positive ethical orientations toward genetic engineering of plants and animals. The behavioral outcomes should be a greater congruence between scientific evidence and public opinion.

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