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How does public perception of antibiotic use on dairy farms contribute to self-reported purchasing of organic?

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The United States regulates the use of antibiotics in agricultural settings to address the global antibiotic resistance problem. Conventional dairy cows treated with antibiotics are kept in the herd and after the withholding period milk is harvested. On organic farms, the US organic standard on antibiotic use requires sick dairy cows to be treated, but treated cows must be removed from the herd and their milk can never again be sold as certified organic. This study investigated the US public's perceptions of the organic dairy farming, antibiotic use on dairy farms, and whether these perceptions affect consumer's self-reported purchasing behavior for organic. We used a nationally representative phone-based survey of 1000 US adults and characterized participants' self-reported (i) knowledge of the legality of antibiotic use on dairy farms (conventional and organic) and (ii) frequency of purchasing organic instead of conventional dairy products, as well as several demographic and other variables. The results indicated that participants' knowledge about antibiotic use practices in dairy farming have no effect on their self-reported purchasing behavior for organic or conventional dairy products. However, respondents who were familiar with the regulations of antibiotic use on dairy farms were more likely to oppose the US organic standard on antibiotic use in dairy farming and thought that past antibiotic use should not permanently remove a cow's organic status. These findings contribute to understanding of public perceptions that shape the US dairy organic market.

Practical Application: Income, employment, health and political values, but not consumers' knowledge about antibiotic use in dairy farming, affect self-reported purchasing behavior for organic dairy products. However, consumers who are familiar with the regulations of antibiotic use on US dairy farms disagree with the US organic standard on antibiotic use mandating loss of organic status for any cattle treated with antibiotics. These findings may be useful to organic markets.

KEYWORDS
antibiotic use, antibiotic resistance, dairy farming, organic, Public perceptions, purchasing behavior

1 | INTRODUCTION

The general public, specifically the individuals who consume animal products, can support new regulations and demand products consistent with their expectations and concerns, and consequently can affect farming practices (Barkema et al., 2015; Gross & Bruckmaier, 2019; von Keyserlingk et al., 2013; Weary et al., 2016; Wemette et al., 2020). For organic dairy farming, increasing public demand has resulted in market growth (USDA, 2019). The reason for increase in demand has been associated with consumer perceptions, as organic food is believed to be healthier, environmentally friendly, and providing higher animal welfare standards compared to its conventional counterparts (Harwood & Drake, 2018; Schleenbecker & Hamm, 2013; Van Loo et al., 2013). It has been suggested that these perceptions are linked to exclusion of the use of antibiotics, hormones and synthetic chemicals, as well as genetic modifications, which consumers view as unnatural, unnecessary, and/or harmful (Clark et al., 2016; Schwendel et al., 2015; Singer et al., 2019). In addition to the public demand, organic dairy farming in the United States is shaped by regulations, which among other aspects regulate antibiotic use. Specifically, United States Department of Agriculture (USDA) has enforced standards for organic animal production, including dairy cattle, in the United States regarding antibiotic use, which thereafter will be referred to as the "US organic standard on antibiotic use" (USDA, 2002). Accordingly, organic dairy producers may use antibiotics to treat disease in their cattle; however, they cannot market as organic products from treated cattle. If antibiotics are used in treatment, the organic status of the animal is lost, and the animal must be separated from the organic herd entirely (Habing et al., 2016; Pol & Ruegg, 2007; Schwendel et al., 2015). However, organic farmers are legally not allowed to withhold antibiotic treatment from a sick animal in order to maintain its organic status (USDA, 2013). The Veterinary Feed Directive (VFD) is another regulation of antibiotic use implemented in the United States by FDA to promote more judicious antibiotic use in animal agriculture (organic and conventional). According to the VFD, medically important antibiotics (i.e., important for treating human disease) in food-producing animals are no longer allowed in the United States for growth promotion nor to improve feed efficiency (FDA, 2015, 2017).

As there are indications that consumers' perceptions about the use of antibiotics in animal production systems affect US dairy market and farming practices, a more thorough understanding of consumer attitudes regarding antibiotic use, including relevant regulations, is needed (Busch et al., 2020; Goddard et al., 2017; Lusk et al., 2006). In general, we do not know whether consumers are against any antibiotic use on dairy farms, or if they perceive it as a permissible treatment option for sick animals in moderation. In addition, consumers' concerns regarding antibiotic resistance in dairy production have yet to be accounted for.

The objective of this study was to investigate perceptions of the public regarding organic and conventional dairy farming practices, especially in relation to antibiotic use, as well as to assess whether these perceptions may be associated with their recollection of decisions about purchasing organic dairy products. Additionally, the goal was to initiate discussion of the values and conflicts that shape antibiotic use in the current dairy farming system (organic and conventional) with a long-term goal of identifying factors that could be subsequently targeted to promote socially, economically, and environmentally sustainable antibiotic use practices in animal farming.

2 | MATERIALS AND METHODS

2.1 | Survey design and data collection

A cross-sectional study based on a questionnaire survey was conducted as part of the Cornell National Social Survey (CNSS), developed in collaboration with the Survey Research Institute (SRI) of Cornell University. The CNSS was conducted with the approval of Cornell University's Internal Review Board (approval #1402004459A003) and informed consent was obtained from each subject prior to their participation in the study (Supporting Information). Data were collected by SRI through dialing random numbers to obtain a nationally representative sample of 1000 participants, who were individuals of 18 years of age or older (adults) and residing in the continental United States. The numbers were generated via a method called Random Digit Dialing (RDD), which has the advantage of including unlisted numbers since the numbers are not selected from a phonebook but generated at random using all possible numbers that could be assigned to a household. More details on sampling methodology can be found in Supporting Information and Survey Research Institute at Cornell University (2018).

TABLE 1 Questions on perceptions of organic dairy farming practices and antibiotic use on dairy farms, and the related organic dairy product purchasing decisions, contributed to the 2018 Cornell National Social Survey

No.	Survey question	Options	Variable name[a]
Q1	What does "organic" mean to you when buying dairy products?	(i) Answer in participant's own words (ii) Do not know (iii) Refused	Respondent's definition of "organic"
Q2	How familiar are you with dairy farming practices?	(i) Very familiar (ii) Somewhat familiar (iii) Slightly familiar (iv) Not at all familiar (v) Do not know (vi) Refused	Familiarity with dairy farming
Q3	In the past 6 months, how frequently have you purchased organic dairy products instead of conventional dairy products?	(i) Never (ii) Rarely (iii) Sometimes (iv) Often (v) Always (vi) Do not know (vii) Refused	Purchasing behavior
Q4	Which of the following is the single most important reason you choose to purchase organic dairy products instead of conventional dairy products?	(i) The natural environment (ii) Human health (iii) Animal welfare (iv) Farmworker treatment (v) Antibiotic resistance prevention (vi) Other (vii) Do not know (viii) Refused	Reason for purchase
Q5	In which of the following situations, it is legal to use human antibiotics on US dairy farms?	(i) To treat or prevent cow illness (ii) To promote cow growth (iii) Both (iv) Neither (v) Do not know (vi) Refused	Knowledge of VFD
Q6	Please state your level of agreement with the following practice: If a dairy cow on organic dairy farm is given an antibiotic to treat illness, its milk should NEVER again be sold as organic for the rest of the cows' life.	(i) Strongly disagree (ii) Disagree (iii) Neither agree nor disagree (iv) Agree (v) Strongly agree (vi) Do not know (vii) Refused	Agreement with US organic standard on antibiotic use

Abbreviation: VFD, Veterinary Feed Directive.

[a]Variable name used in statistical analysis.

2.2 | Survey questions

The 2018 CNSS included questions about standard sociodemographic characteristics, as well as questions covering a range of topics submitted by researchers at Cornell University, and selected for including into the survey by the SRI Advisory Board. Included in the survey were the questions contributed by the authors of this study (thereafter referred to as "survey questions"). For the current study, a total of 19 demographic questions along with the six survey questions the authors contributed (listed in Table 1) were chosen from the 2018 CNSS to investigate characteristics and perceptions of the study population. The six survey questions (Qs) were used to describe public perception of organic dairy farming practices and antibiotic use on dairy farms (Q1—respondent's definition of

"organic", Q2—familiarity with dairy farming, Q4—reason for purchase, Q5—knowledge of VFD, and Q6—agreement with the US organic standard on antibiotic use), as well as to investigate possible reasons for the self-reported purchasing behavior for organic instead of conventional dairy products (Q3—purchasing behavior).

The wording of these survey questions was based on a pilot study that SRI conducted to obtain 25 surveys; wording of questions and/or responses for questions Q1, Q2, Q4, and Q5 (Supporting Information) were revised for clarity based on the pilot results while our pre-pilot versions of Q3 and Q6 remained unchanged.

2.3 | Data processing and analysis

Demographic characteristics of the survey sample, including age, gender, race, ethnicity, employment status, annual household income, and education were compared to the US Census data estimated by the US Census and Bureau of Labor Statistics by one-sample z test.

Response rate and cooperation rate calculations were carried out by SRI, according to the guidelines provided by the American Association for Public Opinion Research (AAPOR) (The American Association for Public Opinion Research, 2016). Specifically, the response rate is the total number of survey completions divided by the total "eligible sample" that was obtained after excluding from the dialed randomly generated numbers all nonworking numbers, numbers with unknown eligibility, nonresidential numbers and ineligible respondent numbers [minor's cell phone number or ineligible due to quota limits]. Cooperation rate is the total number of survey completions divided by the "cooperating sample" that included completed surveys plus the refusals. See detailed description in Supporting Information.

Demographic variables included in this study were age, gender, education level, household income, census region, employment status, being born in the United States, home ownership status, race, being Hispanic/Latino, number of adults in the household, number of children in the household, marital status, political party affiliation, social ideology, religious practice, frequency of attendance at religious services, rural versus urban area of residency, and whether the survey was taken via landline or cell phone (Table 2). Our survey questions were multiple choice except for Q1 (respondent's definition of "organic"), which was an open-ended question and required the respondent to provide feedback in their own words. These qualitative responses were transcribed and then analyzed separately using primarily a qualitative, thematic analysis (Patton, 2015). The goal of this type of analysis is to assess the nature and the range of ways that participants described what "organic"

TABLE 2 Demographic variables describing characteristics of 2018 Cornell National Social Survey respondents[a]

Demographic variables sample size = 1000	Number	Percent[b]
Gender		
Male	493	49.8
Female	492	49.7
Other	5	0.5
Refused	10	–
Education level		
High school (grade 12 or GED certificate) or less	245	24.7
Technical, trade, or vocational school after high school, or some college, no 4-year degree (including 2-year Associate degree)	258	26.0
College graduate (BS, BA, or other 4-year degree)	267	26.9
Post-graduate training or professional schooling after college	222	22.4
Refused	8	–
Household income		
Under $50,000	271	28.1
$50,000 to under $100,000	347	36.0
$100,000 or over	346	35.9
Do not know	6	–
Refused	30	–
Census region		
Northeast	216	21.6
Midwest	240	24.0
South	334	33.4
West	210	21.0
Born in the United States		
No	115	11.5
Yes	884	88.5
Refused	1	–
Employment status		
Employed	669	66.9
Unemployed	149	14.9
Not in labor force (retired, disabled, unable to work)	182	18.2
Hispanic or Latino		
No	885	89.4
Yes	105	10.6
Refused	10	–
Home ownership status		
Own or live there rent free	667	67.2
Rent	325	32.8

(Continues)

TABLE 2 (Continued)

Demographic variables sample size = 1000	Number	Percent[b]
Refused	8	–
Race		
Caucasian only	788	80.0
African-American only	120	12.2
Native American only	70	7.1
Asian only	60	6.1
Other only[c]	33	3.4
Refused	15	–
Adults (age 18–64) in household		
No	153	15.3
Yes	847	84.7
Children in household		
No	642	64.2
Yes	358	35.8
Marital status		
Single, formerly married (divorced, separated, widowed), other[d]	486	48.9
Married	508	51.1
Refused	6	–
Political party		
Democrat	279	28.3
Independent or other[e]	465	47.1
Republican	243	24.6
Refused	13	–
Social ideology		
Liberal	371	37.7
Moderate	319	32.4
Conservative	295	29.9
Refused	15	–
Religious		
No	301	30.6
Protestant, Catholic, Christian Orthodox	600	61.0
Jewish, Muslim, other religion	82	8.4
Refused	17	–
Frequency of attendance at religious services		
Once a week or more often	261	26.4
Once a month to once a year	307	31.0
Seldom to never	421	42.6
Refused	11	–
Rural versus urban area of residency[f]		
Urban	741	74.1
Rural	259	25.9
Cell or landline phone for survey		
Landline	150	15.1
Cell phone or voice over IP	847	84.9
Refused	3	–

[a]The median for age of participants ($n = 1000$) was 47.0 (interquartile range: 61–31 = 30) years.
[b]Percentages were calculated after excluding "Refused" and "Do not know".
[c]"Other only" includes one of each response of "Mexican," "Mexican-American," "Arab," "Hispanic," "Central American," "Middle Eastern," "Latina," "Ukrainian Jew," "Mestizo," "Puerto Rican," "Egyptian," "Afro-Caribbean," "Chicano," and "Mixed."
[d]Other includes one of each response of "none of the above" and "it is a long story."
[e]Other includes one of each response of "anarchist," "don't vote/don't identify/none," and "socialist."
[f]Rural area is defined as a suburban county of a metropolitan urban area, or an area not in a metropolitan in urban area; metropolitan urban areas are associated with at least one urbanized area with a population of at least 50,000 according to 2003 definition by US Office of Management and Budget.

meant to them and to assess if there was a general agreement, and if not, to identify the topics that were more or less frequent. Statements/answers of participants were reviewed while noting both a priori topics of interest and emergent topics. Once the codebook was finalized, each response was reread to assign all applicable codes. The coder re-reviewed all assignments to ensure consistency. See detailed description in Supporting Information. The remaining variables, including the five survey questions (Qs 2–6) and 19 demographic variables, were included in the descriptive and predictive analyses. Descriptive statistics were used to summarize continuous (median and interquartile range) and categorical (frequencies and percentages) variables. Among all the variables, age was the only continuous variable, while the rest were categorical. The responses of "do not know" and "refused" were excluded from the analyses for all the survey questions except for when participants were asked about their familiarity with the VFD (Q5). For Q5, we asked participants to choose the situation in which human antibiotic use was legal on US dairy farms. The correct answer to the question was "To treat or prevent cow illness" and the option "do not know" was categorized as lack of knowledge and grouped with incorrect responses for predictive statistical analysis (i.e., incorrect answers were "to promote cow growth," "both," "neither," and "do not know"). Two out of the five survey questions were defined as the outcomes of interest, that is, dependent variables: (Outcome 1—Q3) purchasing behavior and (Outcome 2—Q5) knowledge of VFD. For analysis of possible predictors of the Outcome 1, two suboutcomes were created: Outcome

1-i and Outcome 1-ii. Outcome 1-i (termed "ever purchasing") categorizes respondents into those who ever versus never purchased organic products over the past six months (i.e., levels "rarely," "sometimes," "often," or "always" versus "never"—reference level) and it was intended to identify predictors for whether the respondents self-reported to have purchased organic instead of conventional dairy products. The Outcome 1-ii (termed "purchasing frequency") categorizes respondents who purchased organic products over the past six months into those who did that frequently versus rarely (i.e., "sometimes," "often," or "always" vs. "rarely"—reference level) and it was intended to identify independent variables that influenced the self-reported frequency of purchasing organic products.

Univariable logistic regression models were used to determine which of the potential predictor variables were statistically associated with each outcome. Included in these analyses were 22 predictor variables, that is, three survey questions and 19 demographic variables. One exception to the process of constructing univariable models was for Outcome 1-i, where Q4 (reason for purchase) was not included as an independent variable, as it was about reasoning for purchasing organic dairy products and was not applicable for respondents who did not purchase organic instead of conventional dairy products. Statistically significant ($p < 0.05$) variables from univariable analyses were considered in a multivariable backward stepwise logistic regression. Stepwise model selection procedure involved likelihood ratio test (LRT), which was used to compare the fit between nested models and used to indicate whether a given variable should be included in the final model or eliminated from the model based on the significance threshold ($p < 0.05$). Possible two- and three-way interactions between variables were also investigated and statistical significance of their effects in the final model was examined using LRT ($p < 0.05$). Akaike information criterion (AIC) and the Hosmer and Lemeshow goodness-of-fit (HL) statistic was used to determine if the final model was a good fit to the data. AIC compares multiple models, with or without various independent variables included in the model, and ranks them by penalizing additional variables—a lower AIC indicates better fit. The HL statistic divides data in multiple subgroups, finds if the observed event probabilities match the estimated probabilities within each subgroup—a higher p value of the test statistic indicates a better fit, p value > 0.05 was used as a threshold. Odds ratio (OR) and the associated profile likelihood 95% confidence interval (CI) was considered as the measure of the influence of a variable in the univariable and the final multivariable logistic regression models. Wald test-based p values were also reported for the variables in final multivariable models. For each outcome, the variables included in the final model were evaluated for confounding, where a confounder was defined as the non-intervening variable associated with both the outcome and an explanatory variable and whose addition to the model results in a 20% or greater change in OR of another variable in the model (Dohoo et al., 2012); however, no meaningful confounding effects were identified. Correction for multiple testing was done by false discovery rate (FDR). All data were analyzed using R Studio.

3 | RESULTS AND DISCUSSION

3.1 | Respondent demographics

A total of 15995 randomly generated numbers were dialed and 1000 surveys were completed. Within the dialed numbers, the total eligible and cooperating samples were 4973 and 1715, respectively, with a resulting response rate of 20.1% and cooperation rate of 58.3%.

For the survey participants (1000), the median age was 47 years, 80.0% self-identified as Caucasian, 71.9% reported an annual household income of over $50,000, 69.4% were religious, and 69.2% were currently/formerly married or nonsingle (Table 2). The predictors with the most missing values due to respondent refusals were religious practice (17), race (15), and social ideology (15) (Table 3).

Survey respondents' age, gender, race, ethnicity, and employment characteristics were not statistically significantly different from those reported in US Census. However, survey respondents had significantly higher annual household income with 72% participants having an annual household income of $50,000 or higher versus 65% in the US Census ($p = 0.002$). Survey participants were also significantly more educated with 49% participants having bachelor's degree in the survey versus only 28% in the US Census ($p < 0.001$).

3.2 | Responses to survey questions

A majority of the survey participants (993/1000) defined "organic" using their own words when asked what "organic" means to them when buying dairy products (Q1). Participants were asked this regardless of their purchasing practices. Thematic analysis based on a priori areas of interest (antibiotics) and emerging categories (i.e., "scam" or "natural") revealed 19 codes or response types, the frequency of which is shown in Figure 1 (Response types of participants who ever versus never purchased organic and who rarely versus frequently purchased organic are provided in Figures S1 and S2, respectively.). Interestingly, more than a third of responders equated organic to mean purity or without additives of any sort yet distinct from

TABLE 3 Responses to survey questions on perceptions of organic dairy farming practices and antibiotic use on dairy farms and the related organic dairy product purchasing decisions

Survey suestionssample size = 1000	Number	Percent[a]
Familiarity with dairy farming (Q2)		
Very familiar	106	10.6
Somewhat familiar	263	26.3
Slightly familiar	274	27.4
Not at all familiar	357	35.7
Purchasing behavior (Q3)		
Never	390	39.0
Rarely	187	18.7
Sometimes	171	17.1
Often	147	14.7
Always	105	10.5
Reason for purchase (Q4)		
The natural environment	29	4.8
Human health	342	56.1
Animal welfare	68	11.2
Farmworker treatment	6	0.9
Antibiotic resistance prevention	32	5.2
Other	133	21.8
No data (because response in Q3 was "Never")	390	–
Knowledge of VFD (Q5)		
To treat or prevent cow illness	431	43.2
To promote cow growth	29	2.9
Both	171	17.1
Neither	351	35.2
Do not know[b]	16	1.6
Refused	2	–
Agreement with US organic standard on antibiotic use (Q6)		
Strongly disagree	155	15.5
Disagree	282	28.3
Neither agree nor disagree	193	19.4
Agree	200	20.1
Strongly agree	166	16.7
Do not know	3	–
Refused	1	–

[a]Percentages were calculated after excluding "Refused," "Do not know," and "No data."

[b]For subsequent statistical analysis, "Do not know" response was categorized with incorrect responses (i.e., "To promote cow growth," "Both," and "Neither").

hormones (often mentioned separately) and antibiotics (given the specific domain of interest for this). This idea of purity is captured by the label "pure/no chemicals/no pesticides/no additives." Some of the example quotes for this code are as follows: "There are no chemicals, additives, or pesticides to the animals. All of that goes into whether products are organic." "The original earth like they don't have no preservative, no additives, no nothing." The maximum number of categories that a respondent happened to mention in their response was five. Among those who mentioned at least four categories, antibiotics, hormones, and animal welfare were talked about the most frequently when describing organic.

The results indicated poor knowledge and some misconceptions of the general public about VFD (Q5), as 35.2% (351/998) of respondents considered the use of antibiotics in any kind of dairy farming to be illegal, while 20.1% (200/998) thought that antibiotic use for growth promotion is still permitted in the United States (Table 2). Overall, over half of the survey respondents (56.8%, 567/998) failed to correctly identify VFD, which mandates that medically important antibiotics can only be used to treat, prevent, or control cow illness on the US dairy farms. It is commonly recognized that many people in the general public, in the United States and elsewhere, have little experience or information about farming (Boogaard et al., 2011; Christoph-Schulz et al., 2015; J. Hansen et al., 2003).

About a third of participants self-reported lack of familiarity with dairy farming, where 35.7% (357/1000) reported being "not at all familiar" with any kind of dairy farming practice (Q2). Still, most of the respondents (80.3%) were able to form opinions about how antibiotics should be used in organic dairy farming (Q6). Among the respondents, 36.8% (366/997) believed that if an organic dairy cow is given an antibiotic to treat illness, its milk should never again be sold as organic for the rest of the cow's life (i.e., agreement with the US organic standard on antibiotic use), while 43.8% (437/997) reported the antibiotic use in cows to treat illness should not change its organic status.

A substantial portion of the participants (39.0%, 390/1000) reported to have never purchased organic over conventional dairy products (Q3). Among those who self-reported purchasing organic, 56.1% (342/610) reported that human health was the most important reason for purchasing organic, while only 5.2% (32/610) expressed that antibiotic resistance prevention was the most important reason for them to purchase organic products (Q4).

3.3 | Predictors of self-reported purchasing behavior

Univariable analyses revealed 9 out of 22 considered variables as possible predictors of respondents who reported to ever purchase organic instead of conventional dairy products (vs. never; Table 4, Outcome 1-i). Multivariable logistic regression analyses identified the best predictors

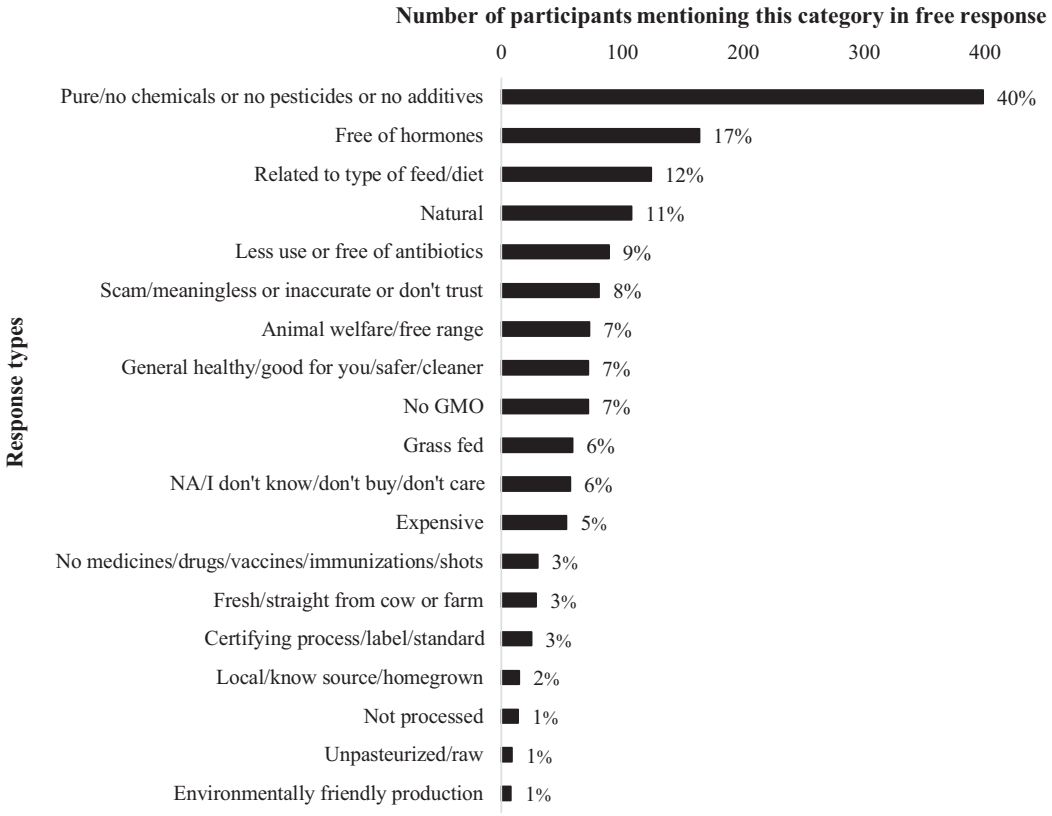

FIGURE 1 What does "organic" mean to you when buying dairy products?" Frequency of 19 response types collected from 993 participants for thematic analysis of the 2018 Cornell National Social Survey. Percentage of participants for each response type were given next to associated bar. Individual's responses could have components that each fall into a separate category. Each applicable category was marked for an individual response. The maximum number of categories applied to any one response was 5.

of respondents who reported to ever purchase organic (Table 5, Figure 2), which included household income, being born in the United States and political party. The final logistic regression model had an AIC of 1148.1 and a residual deviance of 1136.1 on 885 degrees of freedom. The null model has an AIC of 1192.4 and a residual deviance of 1190.4 on 890 degrees of freedom. An LRT revealed that the fit of these models was significantly different ($p < 0.001$). HL test suggested a good fit for the final multivariable logistic regression model (10 bins/intervals, $\chi^2 = 3.52$, $df = 8$, $p = 0.90$). No interaction was identified.

Compared to the lowest income group, respondents with the highest income had the highest odds of purchasing organic instead of conventional dairy products (Table 5). Specifically, the odds of purchasing an organic dairy product were nearly twice as large for the respondents with an annual income of $100,000 or over, compared with the respondents with an annual income under $50,000.

The study identified a positive association between being born outside of the United States and self-reported ever purchasing of organic dairy (Table 5): For a foreign-born respondent, the odds of purchasing of organic were about three times as large as the odds of purchasing of organic for a US-born respondent. In addition, respondents who self-reported purchasing organic dairy were more likely to describe themselves as Democrats compared to being self-described as a Republican. Consumers with liberal views, which likely are characteristics of participating Democrats, have been shown to prefer organic products in previous studies (Bellows et al., 2008; Bullock et al., 2017). In addition, behavioral difference between Republicans and Democrats might be associated with their differences in various moral judgments (Graham et al., 2009; Haidt, 2007).

Univariable analyses revealed 10 out of 22 considered variables as possible predictors of self-reported purchasing frequency (frequently vs. rarely) for organic dairy products (Table 6, Outcome 1-ii). Multivariable logistic regression analyses revealed that the best predictors of purchasing frequency of organic products were familiarity with dairy farming (Q2), reason for purchase (Q4), employment status, being born in the United States, and household income (Table 7, Figure 2). Sample size for the final model was 610, since Q4 (reason for purchase) was applicable only to participants who self-reported to have purchased organic during the past six months. The final model

TABLE 4 Characteristics of 2018 Cornell National Social Survey respondents that were different ($p < 0.05$) among those who ever purchased organic instead of conventional dairy products in the past 6 months (i.e., levels "Rarely," "Sometimes," "Often," or "Always" in Q3) compared to those who "Never" purchased organic products (reference level) in univariable logistic regression analysis

Demographic variables	OR	95% CI
Gender ($n = 985$)		
Male	1.00 (ref)	
Female	1.33	1.03–1.72
Education Level ($n = 992$)		
Highschool or less	1.00 (ref)	
Technical trade, vocational school after high schooling, or some college, or college graduate	1.09	0.79–1.49
Post-graduate training or professional	1.69	1.17–2.45
Household Income ($n = 964$)		
Under $50,000	1.00 (ref)	
$50,000 to under $100,000	1.56	1.10–2.15
$100,000 or over	2.24	1.61–3.13
Born in the United States ($n = 999$)		
Yes	1.00 (ref)	
No	3.02	1.89–5.00
Marital status ($n = 994$)		
Single, formerly married (divorced, separated, widowed), other	1.00 (ref)	
married	1.39	1.08–1.79
Political party ($n = 920$)		
Democrat	1.00 (ref)	
Independent	0.79	0.57–1.12
Republican	0.59	0.44–0.81
Social ideology ($n = 985$)		
Liberal	1.00 (ref)	
Moderate	0.74	0.55–1.01
Conservative	0.53	0.38–0.72
Religious ($n = 983$)		
No	1.00 (ref)	
Protestant, Catholic, Christian Orthodox	0.90	0.68–1.19
Jewish, Muslim, other religion	1.73	1.05–2.84
Frequency of attendance at religious services ($n = 989$)		
Never	1.00 (ref)	
A few times a year to seldom	1.53	1.09–2.13
Once or twice a month or more	1.16	0.83–1.62

Abbreviations: 95% CI: 95% confidence interval (based on profile likelihood); *n*, number of responses; OR, odds ratio; ref, reference level for calculation of odds ratio.

TABLE 5 Final multivariable logistic regression model for respondents who ever (i.e., levels "Rarely," "Sometimes," "Often," or "Always" in Q3) purchased organic instead of conventional dairy products compared to those who "Never" purchased organic products (reference level) among 891 respondents

Demographic variables	OR	95% CI	*p* value
Household ncome			
Under $50,000	1.00 (ref)		
$50,000 to under $100,000	1.60	1.13–2.26	0.008
$100,000 or over	2.02	1.43–2.86	<0.001
Born in United States			
Yes	1.00 (ref)		
No	3.06	1.83–5.34	<0.001
Political party			
Democrat	1.00 (ref)		
Independent	0.78	0.54–1.14	0.194
Republican	0.54	0.39–0.74	<0.001

Abbreviations: 95% CI, 95% confidence interval (based on profile likelihood); OR, odds ratio; ref: reference level for calculation of odds ratio.
p value is based on Wald test.

had an AIC of 753.85 and a residual deviance of 735.85 on 573 degrees of freedom. The null model has an AIC of 792.92 and a residual deviance of 790.92 on 581 degrees of freedom. LRT indicated these models differed significantly ($p < 0.001$). HL test suggested a good fit for the final model (14 bins/intervals, $\chi^2 = 16.82$, $df = 12$, $p = 0.16$).

Respondents who self-reported purchasing organic frequently (vs. rarely) were more likely to describe themselves as being familiar with dairy farming practices (Table 7). They also were more likely to choose human health as the most important reason to buy organic, compared to the aggregate of natural environment, animal welfare, farmworker treatment, antibiotic resistance prevention or other nonhealth-related concerns. Employed respondents tended to purchase organic dairy products more frequently, compared with the aggregate of unemployed, retired, disabled respondents or respondents that are unable to work. There was an interaction between household income and country of birth: a positive association between income and purchasing frequency for organic dairy was observed among respondents who reported to be born outside the United States. Compared to those in the lowest income group, foreign-born respondents with the highest income had the highest odds of purchasing organic frequently. However, the associations for foreign-born participants had wide confidence intervals, which attributed to the small sample size (only four and nine foreign-born respondents in the lowest and middle-income group, respectively, self-reported purchasing organic rarely).

Respondents who self-reported purchasing organic frequently were those who considered themselves as more

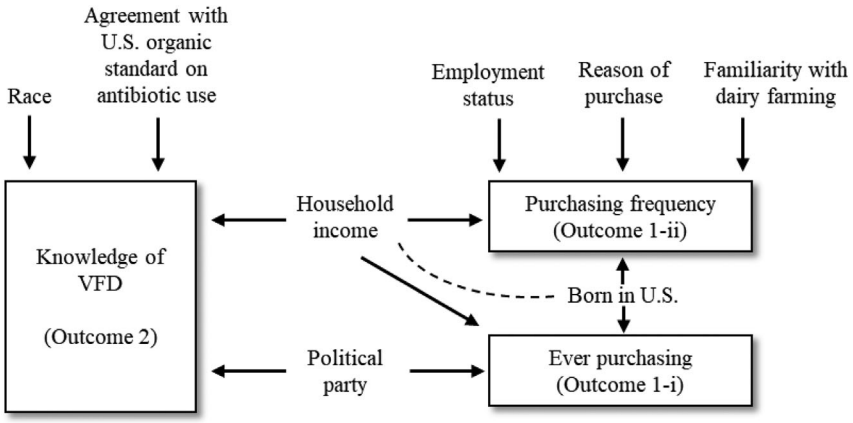

FIGURE 2 Causal diagram for 2018 Cornell National Social Survey indicating the best predictor variables for Outcomes 1-i, 1-ii, and 2. Dashed line shows the interaction between independent variables for Outcome 1-ii.

familiar with dairy farming (Table 7, Figure 2). This was expected, as perceived familiarity or perceived knowledge (which is different from the factual knowledge such as knowledge of a regulation) was identified as a critical factor affecting consumer behavior (Ladwig et al., 2012). Previous studies showed that consumers with increased perceived knowledge about food production or consumers who feel more familiar with organic products were more likely to purchase organic food (Bellows et al., 2008; Hidalgo-Baz et al., 2017).

For more than half of the respondents who self-reported to purchase organic dairy products, the most important reason to purchase organic more frequently was their own health. Further, respondents who prioritize human health had higher odds of purchasing organic dairy more frequently compared to the respondents who prioritized natural environment, animal welfare, farmworker treatment, antibiotic resistance prevention or other nonhealth related concerns. Our results support previous research on organic consumer motivations indicating that personal benefits, such as one's own health, can be a major driving force for organic food purchase, compared to common benefits, such as environmental health and animal welfare (Lockie et al., 2002; Molyneaux, 2007; Wier et al., 2003). The general public associates "healthy" milk with the characteristics of organic dairy farming as well (Cardoso et al., 2016). Given the positive association between prioritizing human health and purchasing frequency for organic, our results suggest that dairy industry must meet the desire for what public perceives as healthy to retain the demand for organic products (Barkema et al., 2015; von Keyserlingk et al., 2013).

Our results suggested household income was the key element in self-reported purchasing behavior and helped explain why some people purchase organic more frequently than others, as it was identified among the strongest predictors in both of our models for self-reported purchasing behavior (Tables 5 and 7, and Figure 2). Respondents who self-reported to purchase organic most frequently were the respondents with the highest income. We know from earlier studies that consumers of organic dairy products have been shown to be high income earners (Alviola IV & Capps, 2010; Ellis et al., 2009; Gracia & de Magistris, 2008; Harwood & Drake, 2018; Pearson et al., 2011; Van Loo et al., 2013).

3.4 | Predictors of knowledge of VFD

Univariable analyses revealed 10 out of 22 considered variables as possible predictors of knowledge of VFD (Table 8, Outcome 2). Multivariable logistic regression analyses identified the best predictors of knowledge of VFD (Table 9, Figure 2), which included household income, political party affiliation, being identified as Caucasian and agreement with the US organic standard on antibiotic use (Q6). The final model and the null model yielded AIC values of 1179.8 (residual deviance of 1165.8 on 874 degrees of freedom) and 1209.3 (residual deviance of 1207.3 on 880 degrees of freedom), respectively. The LRT revealed that the fit of these two models were significantly different ($p < 0.001$). HL test revealed a good fit between the finalized model and survey data (7 bins/intervals, $\chi^2 = 0.83$, $df = 5$, $p = 0.98$). No interaction was identified.

Respondents who correctly identified VFD were more likely to describe themselves as Republicans (compared to being described as a Democrat) were of Caucasian race (compared to non-Caucasian races) and had higher household income (compared to household income lower than $50,000).

Those respondents who thought past antibiotic use should not permanently exclude a cow from organic status were more likely to know that antibiotics were allowed in US dairy farms to treat or prevent disease and not for growth promotion. In other words, respondents who were familiar with the VFD disagreed with the US organic

TABLE 6 Characteristics of 2018 Cornell National Social Survey respondents that were different ($p < 0.05$) among those who more frequently (i.e., levels "Sometimes," "Often," and "Always" in Q3) purchased organic instead of conventional dairy products compared to those who "Rarely" purchased organic products (reference level) in univariable logistic regression analysis

Characteristics	OR	95% CI
Survey questions		
Familiarity with dairy farming (Q2, $n = 610$)		
Not at all familiar	1.00 (ref)	
Any other level of familiarity	1.50	1.06–2.12
Reason for purchase (Q4, $n = 610$)		
The natural environment, animal welfare, farmworker treatment, antibiotic resistance prevention or other reasons	1.00 (ref)	
Human health	1.83	1.32–2.56
Demographic variables		
Education level ($n = 604$)		
Highschool or less	1.00 (ref)	
Technical, trade, or vocational school after high school, or some college, or college graduate	1.01	0.67–1.54
Post-graduate training or professional	1.69	1.06–2.72
Household income ($n = 583$)		
Under $50,000	1.00 (ref)	
$50,000 to under $100,000	1.87	1.25–3.16
$100,000 or over	2.57	1.64–4.07
Born in United States ($n = 609$)		
Yes	1.00 (ref)	
No	1.73	1.11–2.71
Employment status ($n = 610$)		
Unemployed, retired, disabled, unable to work	1.00 (ref)	
Employed	1.89	1.33–2.70
Hispanic or Latino ($n = 603$)		
No	1.00 (ref)	
Yes	0.54	0.30–0.93
Children in household ($n = 610$)		
No	1.00 (ref)	
Yes	1.44	1.03–2.01
Marital status ($n = 605$)		
Single, formerly married (divorced, separated, widowed), other	1.00 (ref)	
Married	1.51	1.09–2.10
Social ideology ($n = 602$)		
Liberal	1.00 (ref)	
Moderate	0.73	0.50–1.06
Conservative	0.55	0.36–0.84

Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval (based on profile likelihood); n, number of responses; ref, reference level for calculation of odds ratio.

standard on antibiotic use (Figure 2). A similar result was observed for the European public, where respondents who had general knowledge about antibiotics (including regulations in animal husbandry and/or scientific background about antibiotic use) view antibiotics as beneficial, rather than risky (Alexa et al., 2019). Since our results indicated that better understanding of VFD was associated with an increased acceptance of antibiotic use in organic animals for treatment purposes, it suggests that consumers are not inherently against any antibiotic use on organic dairy farms. It appears that consumers with increased VFD understanding were more likely to perceive antibiotic use as a permissible option for disease treatment or prevention in organic production. Therefore, improving public understanding on industrial/scientific or regulatory perspectives could overcome the knowledge deficit and may reshape public's opinion about farming practices regarding antibiotic use. A key aspect towards improving understanding is finding the "how to" aspect of informing the public. This is a complex issue since opinions are not simply changed by facts, but they are influenced by various factors such as moral values, religious beliefs, and political views (Brossard & Nisbet, 2007). For example, individuals may have opinions that do not match facts and consequently they may not search out information since they "feel" knowledgeable about a topic (Galli, 1978; Ladwig et al., 2012; Radecki & Jaccard, 1995). Even if the consumers were readily presented with the facts, they might not be interested in acquiring information due to challenges in understanding a complex knowledge (Brossard & Nisbet, 2007). Building on our findings, future research could aim to elucidate public perceptions and acceptance of potential modifications in the current standards for antibiotic use in dairy cattle, such as an extended withholding period.

3.5 | Perceptions of antibiotic use and resistance in purchasing behavior

Concerns of the general public over antibiotic use or antibiotic resistance in animal husbandry has been extensively reported in the literature (Barlow, 2011; Clark et al.,

TABLE 7 Final multivariable logistic regression model for respondents who more frequently (i.e., levels "Sometimes", "Often" and "Always" in Q3) purchased organic instead of conventional dairy products compared to those who "Rarely" purchased organic products (reference level) among 610 respondents

Predictors	OR	95% CI	*p* value
Survey questions			
Familiarity with dairy farming (Q2)			
Not at all familiar	1.00 (ref)		
Any other level of familiarity	1.54	1.05–2.24	0.025
Reason for purchase (Q4)			
The natural environment, animal welfare, farmworker treatment, antibiotic resistance prevention or other reasons	1.00 (ref)		
Human health	1.79	1.26–2.55	0.001
Demographic variables			
Employment status			
Unemployed, retired, disabled, unable to work	1.00 (ref)		
Employed	1.78	1.22–2.62	0.003
Born in United States and household income			
Under $50,000	1.00 (ref)		
$50,000 to under $100,000	1.38	0.83–2.31	0.001
$100,000 or over	1.56	0.94–2.62	< 0.001
Born outside United States and household income			
Under $50,000	1.00 (ref)		
$50,000 to under $100,000	9.77	2.64–43.57	0.217
$100,000 or over	11.29	3.43–45.67	0.086

Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval (based on profile likelihood); ref, reference level for calculation of odds ratio.
p value is based on Wald test.

2016; Hwang et al., 2005; Scott et al., 2015; Vanhonacker et al., 2010; Wemette et al., 2021), however in our study, antibiotic resistance prevention was selected as the most important reason for only 5.2% (32/610) of the participants that self-reported purchasing organic products (Q4). Having said that, it is possible that antibiotic resistance prevention was important also for some participants who selected "human health" as the reason for the purchase of organic because it is a broader term that represents their overall health-related concerns. In addition, respondents' agreement with the US organic standard on antibiotic use or their understanding of regulations about antibiotic use was not identified as predictors of self-reported purchasing behavior in any of our models. One way to

TABLE 8 Characteristics of 2018 Cornell National Social Survey respondents that were different ($p < 0.05$) among those whose responses indicated knowledge of the Veterinary Feed Directive (VFD; i.e., level "To treat or prevent cow illness" in Q5) compared to those with lack of knowledge (i.e., aggregate of responses "To promote cow growth", "Both", "Neither" and "Do not know" in Q5, used as the reference level) in univariable logistic regression analysis

Characteristics	OR	95% CI
Survey questions		
Familiarity with dairy farming (Q2, $n = 998$)		
Not at all familiar	1.00 (ref)	
Any other level of familiarity	1.31	1.01–1.71
Agreement with US organic standard on antibiotic use (Q6, $n = 994$)		
Agree	1.00 (ref)	
Neither agree nor disagree	1.42	0.99–2.04
Disagree	1.83	1.38–2.44
Demographic variables		
Household income ($n = 962$)		
Under $50,000	1.00 (ref)	
$50,000 or over	1.52	1.14–2.04
Home ownership status ($n = 990$)		
Rent	1.00 (ref)	
Own or live there rent free	1.59	1.21–2.10
Race: Caucasian only ($n = 983$)		
No	1.00 (ref)	
Yes	2.29	1.64–3.25
Race: African American only ($n = 982$)		
No	1.00 (ref)	
Yes	0.42	0.27–0.63
Race: Other only[a] ($n = 982$)		
No	1.00 (ref)	
Yes	0.41	0.17–0.87
Marital status ($n = 992$)		
Single, formerly married (divorced, separated, widowed), other	1.00 (ref)	
married	1.47	1.14–1.89
Political party ($n = 918$)		
Democrat	1.00 (ref)	
Independent	1.12	0.79–1.59
Republican	1.72	1.28–2.33

Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval (based on profile likelihood); *n*, number of responses; ref, reference level for calculation of odds ratio.
[a]Other only includes one of each response of "Mexican," "Mexican-American," "Arab," "Hispanic," "Central American," "Middle Eastern," "Latina," "Ukrainian Jew," "Mestizo," "Puerto Rican," "Egyptian," "Afro-Caribbean," "Chicano," and "Mixed."

TABLE 9 Final multivariable logistic regression model for knowledge of the Veterinary Feed Directive (VFD; i.e., level "To treat or prevent cow illness" in Q5) compared to lack of knowledge (i.e., aggregate of responses "To promote cow growth", "Both," "Neither," and "Do not know" in Q5, used as the reference level) among 881 respondents

Predictors	OR	95% CI	*p* value
Survey questions			
Agreement with US organic standard on antibiotic use (Q6)			
Agree	1.00 (ref)		
Neither agree nor disagree	1.33	0.91– 1.97	0.504
Disagree	1.52	1.11–2.08	0.143
Demographic variables			
Household Income			
Under $50,000	1.00 (ref)		
$50,000 or over	1.40	1.02–1.91	0.036
Race: Caucasian only			
No	1.00 (ref)		
Yes	1.87	1.29–2.77	0.001
Political party			
Democrat	1.00 (ref)		
Independent	1.21	0.84–1.75	0.294
Republican	1.50	1.09–2.77	0.013

Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval (based on profile likelihood); ref, reference level for calculation of odds ratio.
p value is based on Wald test.

explain this is the attitude-behavior gap, where consumer attitudes (such as concerns over antibiotic resistance or understanding about regulations of antibiotic use) fail to explain actual buying behavior. Consumers show habitual or indecisive purchasing behaviors and various variables may significantly influence actual behavior. These variables can be income, race, education, religion, social pressures, ethical concerns, level of various concerns, accessibility of food products, sensory appeal, desire to maintain a healthy lifestyle, subjective norms, and the role of food in one's life (Basha & Lal, 2019; Bellows et al., 2008; Brossard & Nisbet, 2007; Chekima et al., 2017; T. Hansen et al., 2018; Nuttavuthisit & Thøgersen, 2017; Shaw et al., 2000; Webster, 1975; Wheale & Hinton, 2007; Wheeler et al., 2019).

3.6 | Limitations

There are several limitations to our study. First, for our survey with protected anonymity, it is impossible to verify the truthfulness of responses. Responses might also be affected by social desirability (Q1) and recall bias (Q3), as well as subjectivity (Q3 and Q4). Second, perception is a complex concept affected by diverse factors. Therefore, factors such as personal relevance of antibiotic resistance problem or frame of reference (i.e., knowledge acquired by important individuals' in one's life) may be equally important for assessing public perception about antibiotic use in dairy farming but were not included in the present study. Similarly, determinants of behavioral process were not well characterized by our study, and we acknowledge that variables included in this study cannot capture purchasing behavior in its entirety; in that regard, future work should aim to elucidate a variety of other reasons for purchasing organic (e.g., taste and price). One important limitation is how Q5 was asked: we assessed knowledge on VFD (Q5) by asking about one aspect of the VFD (i.e., ban on antibiotics for growth promotion), but the wording of the question did not exactly match that of VFD (which specifically bans the use of medically important antibiotics for production purposes in food-producing animals in feed and water, and requires veterinary oversight of medically important antibiotics) (FDA, 2017). The chosen wording in Q5 was intended to investigate public understanding of agricultural antibiotic use while reducing the complexity and information density, so that the question is less intimidating and easier for participants to answer. We acknowledge that antibiotics and their use in dairy farms are a complex and highly technical issue for the general public (Carter et al., 2016; Ritter et al., 2019; Vanden Eng et al., 2003); therefore, Q5 may be limited in assessing participants' understanding of regulations regarding antibiotic use. Unlike what was done in our study, perceptions are generally assessed using multi-item scales with a specific central idea (Bruner, 2012). In this study, our central idea was clear; however, various types of questions had to be used as public understanding in our study requires understanding of different concepts, such as antibiotic use and resistance, as well as organic and conventional dairy production. There are also potential limitations associated with the particular categorization used in the thematic analysis (further elaborated in the Supporting Information). While our study had a high cooperation rate, the nature of phone-based survey may have introduced selection bias considering that people who use cell phones or landline phones may have different characteristics from the ones who do not have, as well as people who agree to participate in a phone-based survey from the ones who do not agree. In our survey, the order of the questions asked was the same for each participant, which may have introduced order bias that might affect responses to the questions. When compared to the general US population in 2018, our survey sample was representative to the US

population except that it included participants that were significantly better educated and had higher household income, which could have introduced a selection bias into the study. We thus encourage future work to identify and analyze the responses from a broader assembly of respondents to allow full assessment of generalizability of findings.

4 | CONCLUSIONS

Our study showed that the US public poorly understands the regulations (VFD) regarding antibiotic use in dairy cows. The most important characteristics of consumers who self-reported purchasing organic dairy instead of conventional was the higher household income. Participants who self-reported purchasing organic more frequently were more likely to prioritize their own health. Knowledge about antibiotic use practices in dairy farming did not seem to affect purchasing behavior for organic versus conventional dairy products. Most consumers did not explicitly prioritize their concerns about antibiotic resistance when purchasing organic. These results support the importance of higher income level compared to perceptions on antibiotics. Although participants' knowledge about VFD was not associated with purchasing behavior for organic, we still recognize the need to better inform the public about antibiotic use in animal agriculture. This is because increased understanding about VFD was associated with higher acceptance of antibiotic use for treatment of illness in organic dairy industry. Overall, these findings contribute to understanding of public perceptions that shape the US dairy organic market and inform future educational and research efforts regarding antibiotic use in organic agriculture.

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AUTHOR CONTRIBUTIONS

A.G.S., M.W., A.S., and R.I. designed the survey questions. M.W. assisted A.S. in developing a preliminary statistical analysis plan for the survey data. E.B. conducted statistical analysis of survey data in consultation with R.I. A.G.S. conducted thematic analysis of responses to Q1 in collaboration with R.I. E.B. drafted a manuscript and revised it based on contributions about interpretation of results from all co-authors. All authors approved the final version of the manuscript.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The data produced by the 2018 CNSS are publicly available at https://www.sri.cornell.edu/sri/polls/cnss.cfm, including the protocol, questions, and results.

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REFERENCES

Alexa, E.-A., Likotrafiti, E., Garre, A., Ruiz, L., Prieto, M., & Alvarez-Ordóñez, A. (2019). A European questionnaire-based study on population awareness and risk perception of antimicrobial resistance. *FEMS Microbiology Letters*, *366*(17). https://doi.org/10.1093/femsle/fnz221.

Alviola IV, P. A., & Capps Jr., O. (2010). Household demand analysis of organic and conventional fluid milk in the United States based on the 2004 Nielsen Homescan panel. *Agribusiness*, *26*(3), 369–388. https://doi.org/10.1002/agr.20227

Barkema, H. W., von Keyserlingk, M. A. G., Kastelic, J. P., Lam, T. J. G. M., Luby, C., Roy, J. P., LeBlanc, S. J., Keefe, G. P., & Kelton, D. F. (2015). Invited review: Changes in the dairy industry affecting dairy cattle health and welfare. *Journal of Dairy Science*, *98*(11), 7426–7445. https://doi.org/10.3168/jds.2015-9377

Barlow, J. (2011). Antimicrobial resistance and the use of antibiotics in the dairy industry: Facing consumer perceptions and producer realities. *Advances in Dairy Technologies*, *23*, 47–58.

Basha, M. B., & Lal, D. (2019). Indian consumers' attitudes towards purchasing organically produced foods: An empirical study. *Journal of Cleaner Production*, *215*, 99–111.

Bellows, A. C., Onyango, B., Diamond, A., & Hallman William, K. (2008). Understanding consumer interest in organics: Production values vs. purchasing behavior. *Journal of Agricultural & Food Industrial Organization*, *6*(1), 1–31. https://doi.org/10.2202/1542-0485.1169

Boogaard, B. K., Bock, B. B., Oosting, S. J., Wiskerke, J. S. C., & van der Zijpp, A. J. (2011). Social acceptance of dairy farming: The ambivalence between the two faces of modernity. *Journal of Agricultural and Environmental Ethics*, *24*(3), 259–282. https://doi.org/10.1007/s10806-010-9256-4

Brossard, D., & Nisbet, M. C. (2007). Deference to scientific authority among a low information public: Understanding U.S. opinion on agricultural biotechnology. *International Journal of Public Opinion Research*, *19*(1), 24–52. https://doi.org/10.1093/ijpor/edl003

Bruner, G. C. (2012). Marketing scales handbook: Multi-item measures for consumer insight research. *GCBII Productions*.

Bullock, G., Johnson, C., & Southwell, B. (2017). Activating values to stimulate organic food purchases: Can advertisements increase

pro-environmental intentions? *Journal of Consumer Marketing*, *34*(5), 427–441. https://doi.org/10.1108/JCM-12-2015-1643

Busch, G., Kassas, B., Palma, M. A., & Risius, A. (2020). Perceptions of antibiotic use in livestock farming in Germany, Italy and the United States. *Livestock Science*, *241*, 104251. doi:https://doi.org/10.1016/j.livsci.2020.104251

Cardoso, C. S., Hötzel, M. J., Weary, D. M., Robbins, J. A., & von Keyserlingk, M. A. G. (2016). Imagining the ideal dairy farm. *Journal of Dairy Science*, *99*(2), 1663–1671. https://doi.org/10.3168/jds.2015-9925

Carter, R. R., Sun, J., & Jump, R. L. P. (2016). A survey and analysis of the American public's perceptions and knowledge about antibiotic resistance. *Open Forum Infectious Diseases*, *3*(3). https://doi.org/10.1093/ofid/ofw112

Chekima, B., Oswald, A. I., Wafa, S. A. W. S. K., & Chekima, K. (2017). Narrowing the gap: Factors driving organic food consumption. *Journal of Cleaner Production*, *166*, 1438–1447. https://doi.org/10.1016/j.jclepro.2017.08.086

Christoph-Schulz, I., Salamon, P., & Weible, D. (2015). What about the calves? How society perceives dairy farming. In Dumitra, D. E., Jitea, I. M., & Aerts, S. (Eds.), *Know your food* (pp. 318–324).Wageningen, Netherlands: Wageningen Academic Publishers.

Clark, B., Stewart, G. B., Panzone, L. A., Kyriazakis, I., & Frewer, L. J. (2016). A systematic review of public attitudes, perceptions and behaviours towards production diseases associated with farm animal welfare. *Journal of Agricultural and Environmental Ethics*, *29*(3), 455–478. https://doi.org/10.1007/s10806-016-9615-x

Dohoo, I. R., Martin, S. W., & Stryhn, H. (2012). *Methods in epidemiologic research*. Ver Inc.

Ellis, K. A., Billington, K., McNeil, B., & McKeegan, D. E. F. (2009). Public opinion on UK milk marketing and dairy cow welfare *Animal Welfare*, *18*(3), 267–282.

FDA. (2015). *Veterinary feed directive*. https://www.federalregister.gov/documents/2015/06/03/2015-13393/veterinary-feed-directive.

FDA. (2017). *Fact sheet: Veterinary feed directive final fule and next steps*. https://www.fda.gov/animal-veterinary/development-approval-process/fact-sheet-veterinary-feed-directive-final-rule-and-next-steps.

Galli, N. (1978). How self-perceived knowledge, actual knowledge and interest in drugs are related. *Journal of Drug Education*, *8*(3), 197–202. https://doi.org/10.2190/x9el-b8bu-64kt-8mxb

Goddard, E., Hartmann, M., & Klink-Lehmann, J. (2017). Public acceptance of antibiotic use in livestock production Canada and Germany. *Proceedings in System Dynamics and Innovation in Food Networks*, *1*, 424—437 http://ageconsearch.umn.edu/record/258184/files/43-Goddard%20et%20al._Public%20Acceptance%20of%20Antibiotic%20Use%20in%20Livestock%20Production_Igls%20Proceedings.pdf

Gracia, A., & de Magistris, T. (2008). The demand for organic foods in the South of Italy: A discrete choice model. *Food policy*, *33*(5), 386–396.

Graham, J., Haidt, J., & Nosek, B. A. (2009). Liberals and conservatives rely on different sets of moral foundations. *Journal of Personality and Social Psychology*, *96*(5), 1029–1046. https://doi.org/10.1037/a0015141

Gross, J. J., & Bruckmaier, R. M. (2019). Invited review: Metabolic challenges and adaptation during different functional stages of the mammary gland in dairy cows: Perspectives for sustainable milk production. *Journal of Dairy Science*, *102*(4), 2828–2843. https://doi.org/10.3168/jds.2018-15713

Habing, G., Djordjevic, C., Schuenemann, G. M., & Lakritz, J. (2016). Understanding antimicrobial stewardship: Disease severity treatment thresholds and antimicrobial alternatives among organic and conventional calf producers. *Preventive Veterinary Medicine*, *130*, 77–85. https://doi.org/10.1016/j.prevetmed.2016.06.004

Haidt, J. (2007). The new synthesis in moral psychology. *Science*, *316*(5827), 998–1002. https://doi.org/10.1126/science.1137651

Hansen, J., Holm, L., Frewer, L., Robinson, P., & Sandøe, P. (2003). Beyond the knowledge deficit: Recent research into lay and expert attitudes to food risks. *Appetite*, *41*(2), 111–121. https://doi.org/10.1016/S0195-6663(03)00079-5

Hansen, T., Sørensen, M. I., & Eriksen, M.-L. R. (2018). How the interplay between consumer motivations and values influences organic food identity and behavior. *Food policy*, *74*, 39–52.

Harwood, W. S., & Drake, M. A. (2018). Identification and characterization of fluid milk consumer groups. *Journal of Dairy Science*, *101*(10), 8860–8874. https://doi.org/10.3168/jds.2018-14855

Hidalgo-Baz, M., Martos-Partal, M., & González-Benito, Ó. (2017). Attitudes vs. purchase behaviors as experienced dissonance: The roles of knowledge and consumer orientations in organic market. *Frontiers in Psychology*, *8*(248). https://doi.org/10.3389/fpsyg.2017.00248

Hwang, Y.-J., Roe, B., & Teisl, M. F. (2005). An empirical analysis of united states consumers' concerns about eight food production and processing technologies. *AgBioForum*, *8*(1), 40–49. http://www.agbioforum.org/v48n41/v48n41a06-roe.htm.

Ladwig, P., Dalrymple, K. E., Brossard, D., Scheufele, D. A., & Corley, E. A. (2012). Perceived familiarity or factual knowledge? Comparing operationalizations of scientific understanding. *Science and Public Policy*, *39*(6), 761–774. https://doi.org/10.1093/scipol/scs048

Lockie, S., Lyons, K., Lawrence, G., & Mummery, K. (2002). Eating 'Green': Motivations behind organic food consumption in Australia. *Sociologia Ruralis*, *42*(1), 23–40. https://doi.org/10.1111/1467-9523.00200

Lusk, J. L., Norwood, F. B., & Pruitt, J. R. (2006). Consumer demand for a ban on antibiotic drug use in pork production. *American Journal of Agricultural Economics*, *88*(4), 1015–1033.

Molyneaux, M. (2007). The changing face of organic consumers. *Food Technology* , *61*(11), 22–26.

Nuttavuthisit, K., & Thøgersen, J. (2017). The importance of consumer trust for the emergence of a market for green products: The case of organic food. *Journal of Business Ethics*, *140*(2), 323–337.

Patton, M. Q. (2015). *Qualitative research & evaluation methods: Integrating theory and practice*. SAGE, Publications, Inc.

Pearson, D., Henryks, J., & Jones, H. (2011). Organic food: What we know (and do not know) about consumers. *Renewable Agriculture and Food Systems*, *26*(2), 171–177.

Pol, M., & Ruegg, P. L. (2007). Treatment practices and quantification of antimicrobial drug usage in conventional and organic dairy farms in Wisconsin. *Journal of Dairy Science*, *90*(1), 249–261. https://doi.org/10.3168/jds.S0022-0302(07)72626-7

Radecki, C. M., & Jaccard, J. (1995). Perceptions of knowledge, actual knowledge, and information search behavior. *Journal of Experimental Social Psychology*, *31*(2), 107–138. https://doi.org/10.1006/jesp.1995.1006

Ritter, G. D., Acuff, G. R., Bergeron, G., Bourassa, M. W., Chapman, B. J., Dickson, J. S., Opengart, K., Salois, M. J., Singer, R. S., & Storrs, C. (2019). Antimicrobial-resistant bacterial infections from foods of animal origin: understanding and effectively communicating to consumers. *Annals of the New York Academy of Sciences*, *1441*(1), 40–49. https://doi.org/10.1111/nyas.14091

Schleenbecker, R., & Hamm, U. (2013). Consumers' perception of organic product characteristics. A review. *Appetite*, *71*, 420–429. https://doi.org/10.1016/j.appet.2013.08.020

Schwendel, B. H., Wester, T. J., Morel, P. C. H., Tavendale, M. H., Deadman, C., Shadbolt, N. M., & Otter, D. E. (2015). Invited review: Organic and conventionally produced milk—An evaluation of factors influencing milk composition. *Journal of Dairy Science*, *98*(2), 721–746. https://doi.org/10.3168/jds.2014-8389

Scott, H. M., Midgley, G., & Loneragan, G. H. (2015). Antimicrobials in animal agriculture: Parables and policy. *Zoonoses and Public Health*, *62*(s1), 3–9. https://doi.org/10.1111/zph.12191

Shaw, D., Shiu, E., & Clarke, I. (2000). The contribution of ethical obligation and self-identity to the theory of planned behaviour: An exploration of ethical consumers. *Journal of Marketing Management*, *16*(8), 879–894. https://doi.org/10.1362/026725700784683672

Singer, R. S., Porter, L. J., Thomson, D. U., Gage, M., Beaudoin, A., & Wishnie, J. K. (2019). Raising animals without antibiotics: U.S. producer and veterinarian experiences and opinions. *Frontiers in Veterinary Science*, *6*, 452-452. https://doi.org/10.3389/fvets.2019.00452

Survey Research Institute at Cornell University. (2018). *Cornell National Social Survey (CNSS), 2018*. Ithaca, NY: Cornell Institute for Social and Economic Research. https://doi.org/10.6077/xghx-hv20.

The American Association for Public Opinion Research. (2016). *Standard definitions: Final dispositions of case codes and outcome rates for surveys*. 9th edition. AAPOR. https://www.aapor.org/AAPOR_Main/media/publications/Standard-Definitions20169theditionfinal.pdf.

USDA. (2002). *Organic regulations*. https://www.ams.usda.gov/rules-regulations/organic.

USDA. (2013). *Organic livestock requirements*. https://www.ams.usda.gov/sites/default/files/media/Organic%20Livestock%20Requirements.pdf

USDA. (2019). *Estimated fluid milk products sales report*. https://www.ams.usda.gov/sites/default/files/media/EstimatedFluidProductsMilkSales.pdf.

Van Loo, E. J., Diem, M. N. H., Pieniak, Z., & Verbeke, W. (2013). Consumer attitudes, knowledge, and consumption of organic yogurt. *Journal of Dairy Science*, *96*(4), 2118–2129. https://doi.org/10.3168/jds.2012-6262

Vanden Eng, J., Marcus, R., Hadler, J. L., Imhoff, B., Vugia, D. J., Cieslak, P. R., Zell, E., Deneen, V., McCombs, K. G., Zansky, S. M., Hawkins, M. A., & Besser, R. E. (2003). Consumer attitudes and use of antibiotics. *Emerging Infectious Diseases*, *9*(9), 1128–1135. https://doi.org/10.3201/eid0909.020591

Vanhonacker, F., Van Poucke, E., Tuyttens, F., & Verbeke, W. (2010). Citizens' views on farm animal welfare and related information provision: Exploratory insights from Flanders, Belgium. *Journal of Agricultural and Environmental Ethics*, *23*(6), 551–569. https://doi.org/10.1007/s10806-010-9235-9

von Keyserlingk, M. A. G., Martin, N. P., Kebreab, E., Knowlton, K. F., Grant, R. J., Stephenson, M., Sniffen, C. J., Harner, J. P., Wright, A. D., & Smith, S. I. (2013). Invited review: Sustainability of the US dairy industry. *Journal of Dairy Science*, *96*(9), 5405–5425. https://doi.org/10.3168/jds.2012-6354

Weary, D. M., Ventura, B. A., & von Keyserlingk, M. A. (2016). Societal views and animal welfare science: understanding why the modified cage may fail and other stories. *Animal*, *10*(2), 309–317. https://doi.org/10.1017/s1751731115001160

Webster, F. E., Jr. (1975). Determining the Characteristics of the Socially Conscious Consumer. *Journal of Consumer Research*, *2*(3), 188–196. https://doi.org/10.1086/208631

Wemette, M., Greiner Safi, A., Beauvais, W., Ceres, K., Shapiro, M., Moroni, P., Welcome, F. L., & Ivanek, R. (2020). New York State dairy farmers' perceptions of antibiotic use and resistance: A qualitative interview study. *PLOS ONE*, *15*(5), e0232937. https://doi.org/10.1371/journal.pone.0232937

Wemette, M., Greiner Safi, A., Wolverton, A. K., Beauvais, W., Shapiro, M., Moroni, P., Welcome, F. L., & Ivanek, R. (2021). Public perceptions of antibiotic use on dairy farms in the United States. *Journal of Dairy Science*, *104*(3), 2807–2821. doi:https://doi.org/10.3168/jds.2019-17673

Wheale, P., & Hinton, D. (2007). Ethical consumers in search of markets. *Business Strategy and the Environment*, *16*(4), 302–315. https://doi.org/10.1002/bse.484

Wheeler, S. A., Gregg, D., & Singh, M. (2019). Understanding the role of social desirability bias and environmental attitudes and behaviour on South Australians' stated purchase of organic foods. *Food Quality and Preference*, *74*, 125–134.

Wier, M., Anderson, L. M., & Millock, K. (2003). Consumer demand for organic foods: Attitudes, values and purchasing behavior. Paper presented at SOM Workshop, Frederiksdal, Denmark.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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