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Awareness and use of probiotics among the millennials in the United States: Drivers and implications

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ABSTRACT

Background: Despite the substantial increase in the number of probiotic products available in the U.S. during the last decade and the potential for millennials to be a large market for probiotics, there is a lack of understanding about millennials' awareness, use, and preference for probiotics. This study aims to examine the relationship between the millennials' health and diet perceptions and health outcomes, estimate awareness and use levels of probiotics among the millennials, and identify the drivers of use of probiotics.

Methods: An online opt-in internet panel is used to collect national level survey data on awareness and use of probiotics from the U.S. population in the age group of 21 to 37 years old.

Results: The study finds that there is divergence in millennials' perceptions about their health and diet and health outcomes; awareness about probiotics is high and probiotics use is common among the millennials; demographic, socio-economic, and life style related attributes are influential in millennials' decision on the use of probiotics, and shakes and yogurt are the most preferred carrier forms of probiotics among the millennials. The study also finds that income constraints and perception of good health status are the major factors hindering the use of probiotics among the millennials.

Conclusion: The study shows that millennials are already an important market for probiotics and there is substantial scope for expanding that market. The ability of probiotics to address public health concerns will depend greatly on how health care providers and probiotic industry will leverage these high levels of awareness and use by the millennials. Findings from our study

provide insights that are helpful for probiotics product and market development and outreach efforts that will result in increased use of probiotics among the millennials with positive implications for public health and overall economy.

Keywords: consumer preference, probiotic industry, functional foods, health outcome

BACKGROUND

The increased understanding of the delicate symbiosis between the trillions of microbes that reside in the gastro-intestinal tract and the host has resulted in the development of probiotics [1-3]. Probiotics are live microorganisms, when administered in adequate amounts, confer health benefits to the host [3, 4]. Encouraged by the results from the cutting edge research on the human microbiome facilitated by the high-throughput molecular-profiling technologies, companies are moving beyond the more general health benefits associated with probiotics to a whole new range of targets and therapeutic opportunities for treating complex chronic diseases [2, 5]. The rising research interest in probiotics is further evident from the number of publications and the randomized control trials focusing on probiotics, which increased substantially from 176/year in 2000 to 1,476/year in 2014 [6]. As a result of these supply-side drivers, the number of probiotics marketed as diet supplements or integrated foods in grocery stores and pharmacies have increased in recent years [6, 7].

Rising health concerns across the globe coupled with the efficacy of probiotics in addressing these concerns, increasing disposable income, life-style changes, and broadening of probiotics portfolio are driving the global demand for probiotics as food supplements [8]. The global probiotic industry was worth $35.9 billion in 2016. The rising costs of the healthcare sector and the advent of the internet age increase the preference for preventive health care in the U.S. and drives the growth in the U.S. probiotics market [7, 9]. For example, in 2012 the use of probiotics by adults in the U.S. was four times higher than the use in 2007 [10]. The U.S. probiotic market is characterized by the presence of probiotic products for niche markets such as geriatric population and the youth. The U.S. probiotic market was estimated at $3.3 billion USD in 2015 [11].

Probiotics are of innovative character and in many cases require expensive research and development investment than traditional foods [5, 6]. Although, there are several dozen microbial strains available that are claimed to have probiotic activity, only a handful of species dominate the market or have been used in multiple clinical trials [2]. Some characteristics of probiotics are common; however, there are also differences. Hence there is a need for substantial R&D investment to develop innovative strains or combination of strains for developing probiotics. However, the long term market success of probiotics will depend on several factors, including accurate consumer information, effective marketing strategies, development of quality products that fulfill consumer expectations, and appropriate pricing strategies [3, 12, 13]. While empirical studies focusing on consumer demand for probiotics are limited, available evidence on factors influencing the demand and use of functional foods suggests the importance of price, brand, convenience and packaging, and carrier form (base product) in consumers' purchasing decisions [12, 14, 15].

Although there are a limited number of empirical studies examining consumers' awareness and use of probiotics in the U.S., those studies are conducted in hospital settings using patients as targeted population with the objective of informing healthcare professionals about patients' awareness and use of probiotics [16, 17]. According to the U.S. Census Bureau, millennials outnumber the baby boomer generation and account for more than a quarter of the U.S. population [18]. Health conscious millennials are reshaping how Americans eat with what is characterized as "millennial effect" on food consumption where they prefer meat proteins, fruits, and vegetables and eat less of frozen foods and readymade meals [19]. Hence probiotics have the potential to be part of their life-style as part of general health maintenance and well-being [8, 9]. Despite the substantial increase in the number of probiotic products available in the U.S. during the last decade, and the potential for millennials to be a large market for probiotics, there is a lack of understanding about millennials' awareness, use, and preference for probiotics.

In this study, we examine the relationship between the millennials' health and diet perceptions and health outcomes, estimate awareness and use levels of probiotics among the millennials, and identify the drivers of use of probiotics. The objectives of this study are to (i) examine the relationship between diet and health perceptions and health outcomes among the millennials in the U.S.; (ii) examine the rates of awareness and use of probiotics by the millennials; (iii) identify the drivers and constraints of use probiotics; and (iv) identify the preferred carrier forms of probiotics.

MATERIALS AND METHODS

In this section, we will present data collection process, descriptive statistics of the data, analytical approaches, and the conceptual model for empirical analysis.

Data

The institutional review board at South Dakota State University approved this study. Prior to the national level survey of millennials, we have conducted a pilot study among the undergraduate students at South Dakota State University during January 2018. The feedback from the pilot study helped us to improve the format and content of the survey instrument.

The national level online survey was completed by a sample of 1,497 respondents, aged between 21 and 37 years old, enrolled in an online Opt-in internet Panel maintained by QuestionPro during March and April 2018. In this study we have defined millennials as those born between 1981 and 1997. Our definition of millennials is more restrictive than the one used by the U.S. Census Bureau, which sets the cutoff years as 1982 and 2000 [20]. Given that in this study we focus on millennials aged between 21-37 years whose use of internet is higher relative to the general population [21], use of an opt-in internet panel as the survey mode is appropriate.

QuestionPro was asked to prescreen sample respondents by age and sex to ensure that the sample was representative of the millennial population in the U.S. The survey collected information on awareness about and use of probiotics, preferred carrier forms for probiotics, constraints for using probiotics, intention to use probiotics in future, level of trust in food industry, use of food labels, and demography characteristics. The question on awareness about probiotics was the very first question in the survey and this question was asked to assess how many of our respondents have heard about the term probiotics. The second question in the survey asked whether they have used any forms of probiotics during the last 30 days. These questions

on awareness and use were structured in this way to avoid any potential bias in responses due to the survey design. Statistical package STATA 15 was used for the data analysis.

Demographic characteristics of the sample are presented in Table 1. While it is possible to compare the sample characteristics such as sex with similar data from U.S. Census Bureau for millennials, direct comparisons with U.S. Census data for most of the other characteristics in Table1 is not possible due to this study's specific focus on 21 to 37 years old in the U.S. population. Similar to the Census data, females account for 50.57% of our sample. It is clear from Table 1 that our sample is ethnically diverse and come from all regions of the U.S. As per the latest U.S. Census Bureau estimates, millennials are more diverse than the generations that preceded them, with 44.2% being part of a minority race or ethnic group [18]. In our sample, about 30% come from a non-white ethnicity background. Further, the study sample also captures the heterogeneity in income and education levels among the millennials.

Table 1. Summary statistics for sample demographic characteristics

Demographic characteristics	Sample
Age (median years)	30
Female (%)	50.57
Education level	
Bachelors' degree or higher (%)	44.0
Currently in a 4-year college (%)	10.7
High School/Diploma	45.3
Employed (%)	68.6
Income level (%)	
Annual income (<30,000)	31.7
Annual income (30-59,000)	34.6
Annual income (60-99,000)	22.2
Annual income (>100,000)	11.6
Married (%)	44.7
Have children (%)	46.9
Ethnicity	
White (%)	70.6
Hispanic/Latino (%)	8.9
Black/African American (%)	10.8
Native American/Alaska Native (%)	0.7
Asian (%)	7.8
Other ethnicity (%)	1.3
Geography	
East coast (%)	32.3
West Coast (%)	14.4
Midwest (%)	27.3
South (%)	26.1
Number of observations (#)	1,497

Source: Authors

Methods

We use tabular analyses to examine the awareness and use levels of probiotics among the millennials. In addition to perceptions on diet and health, we collected information on respondents' height, and weight, and used this information to calculate body mass index (BMI). We used BMI scores to classify participants to the following groups: underweight (BMI <18.5), normal weight (BMI: 18.5-24.99), overweight (BMI: 25-29.99), and obese (BMI>30). We used perception and BMI data and employed tabular and correlation analyses to examine the relationship between perceptions and health outcomes.

In addition to the biometric information on weight and height, the survey also collected information on whether the participants currently have any chronic illness, whether anybody in the family have any chronic illnesses, and whether anybody in their family lost life due to chronic illnesses. Responses to these questions are expected to show us whether there is any relationship between participants' or their family members' health outcomes and their diet and health perceptions and whether these factors are influential in their decision to use or not to use probiotics.

Conceptual model

In this study, millennial's decision processes regarding the use of probiotics is modelled using the random utility framework. From the utility theoretic standpoint, a consumer is willing to use probiotics, if the consumer's utility from using the probiotics minus its price is at least as great as the status quo (i.e. not using probiotics). This decision process can be expressed as equation 1 below:

$$U(1, Y_1\_P; X) \geq U(0, Y_0; X) \quad (1)$$

Where 1 indicates the use of probiotics and 0 indicates not using probiotics (status quo). Y_1 and Y_0 are the expected utilities from using and not using probiotics, respectively; P is the price for purchasing probiotics, and X is vector of consumers' demographic and lifestyle related characteristics.

The consumer's utility function $U(i, Y_{i\,;}\, X)$, where i takes the value of 1 or 0 depending the use of probiotics, is unknown to the researcher. One way to model this process is to assume that there is a latent continuous variable Y_i^* such that

$$Y_i = \begin{cases} 1 \; if \; Y_i^* = X_i \; \beta + \epsilon_i \\ 0 \; otherwise \end{cases} \quad (2)$$

What the researcher can see is the deterministic part of the utility function Y_i, that is whether or not the consumer is using probiotics or not. If N observations are available and specifying $\Pr(y = 1|X)$, the likelihood function for equation (2) is

$$L = \prod_{i=1}^{N} P_i^{Y_i} (1 - P_i)^{1-y_i} \quad (3)$$

The probit model arises when P_i is specified to be given by normal cumulative distribution function evaluated at $X_i'\beta$. If $F(X_i'\beta)$ denotes the cumulative distribution function, then the log-likelihood function is

$$L = \prod_{i=1}^{N} F(X_i'\beta)^{y_i}(1 - F(X_i'\beta))^{1-y_i} \quad (4)$$

The marginal effects can be estimated at the mean values of X as follows:

$$\frac{\partial P_i}{\partial x_{ij}} = f(x_i'\beta)\beta_j,\ i = 1,2,\dots,N; j = 1,2,\dots,K \quad (5)$$

Empirical model

The empirical model we estimate in the study is given below:

$$Y_i = \alpha + \theta X_i + \varepsilon_i \quad (6)$$

In equation 6,Y_i is a binary dependent variable indicating the current use of probiotics and takes the value of 1 if the respondent has used probiotics in the last 30 days, and zero otherwise, i is an index for each respondent, α and θ are parameters to be estimated, X is a matrix of independent variables, and ε_i is the unobserved error term.

Independent variables were chosen based on what is already available in the literature that are influencing consumers' choice of using functional foods/probiotics. The independent variables included in the model are age in years (continuous variable), sex (1= female, 0= male), education level (indicator variable at three levels, currently in college, 4- year college degree or higher, and high school/ vocational where currently in college is the base level), employment status (binary, takes the value of 1 if currently employed and zero otherwise), income (indicator variable at four levels, <$29,9999; $30,000-59,999; $60,000-99,999; and >$100,000 where less than $29,999 is the base level), marriage status (binary variable takes the value of 1 if married, zero otherwise), have children (binary variable takes the value of 1 if have children, zero otherwise), exercise regularly (binary variable takes the value of 1 if exercise regularly, zero otherwise), read food labels before purchase (binary variable takes the value of 1 if reads labels, zero otherwise), binary variable for normal weight where it takes the value of 1 if the respondent has normal weight based on BMI classification and zero otherwise, and binary variable indicating whether anybody in the family have chronic illness.

There is a strong and statistically significant correlation between reading food labels and trust in food package claims. To avoid the issue of multi-collinearity, we have included only read food labels in the final probit model. Similarly, there is a strong and statistically significant correlation between millennial i having chronic illness and somebody in i's family having chronic illness. Additionally, chronic illness is a health outcome which is potentially endogenous. To address the issue of collinearity and endogenity, we use the binary variable indicating presence of family member having chronic illness as a proxy variable for millennials having chronic illness in the model. Similar to the presence of chronic illness, BMI status is a health outcome which is potentially an endogenous variable. To address the endogenity of normal weight, we use predicted values of normal weight instead of the observed values. Normal weight variable is regressed on the following variables: age, sex, education, income, employment status, diet perception status, and health perception status.

RESULTS AND DISCUSSION

Health and diet perceptions and health Outcomes

In the survey we asked the respondents to report their perceptions about diet and health on a 1 to 3 scale, where scale 1 refers to somewhat or very unhealthy, scale 2 refers to somewhat healthy,

and scale 3 refers to very healthy. In our sample, 14.22% considered their diet to be somewhat or very unhealthy, 69.84% considered it as somewhat healthy, and 15.94% considered it as very healthy. The corresponding numbers for perceptions on health were as follows: 10.29% (somewhat or very unhealthy), 63.32% (somewhat healthy), and 25.40% (very healthy). It is clear from correlation analysis (r=0.5, statistically significant at 1%) that the participants who consider their diet healthy also consider themselves to be healthy.

Tabular analysis of our sample using BMI scores show that contrary to their perceptions, majority of our sample are either underweight (6.63%), overweight (26.02%), or obese (27.54), and only 39.82% have normal weight. More than one-third of U.S. adults have obesity [22], and our study shows a more or less similar trend among the millennials too. It is clear from Table 2 that only 40% (28.02 out of 69.84) of those who considered their diet somewhat healthy have normal weight and 55% (8.83 out of 15.94) of those who considered their diet very healthy have normal weight. Similarly, only 36.69% (23.6 out of 64.32) of those who perceive themselves as somewhat healthy have normal weight and 56.25% (14.29 out of 25.40) who perceive themselves to be very healthy have normal weight. Although 85.78 % (69.84+15.94) perceived their diet to be healthy/very healthy and 89.72% (64.32+25.4) perceived themselves to be healthy or very healthy, the fact that only 39.82% of our sample have normal weight shows the disconnect between perception and reality in relation to diet and health. This is further evident from the results from the correlation analysis where we observed a positive and statistically significant correlation between the perception of unhealthy diet and BMI and negative and statistically significant correlation between the perception of very healthy diet and BMI (r=-0.21). Similarly, the correlation between the perception of health status and BMI was negative and statistically significant (r=-0.19). These findings imply that there is a need for outreach efforts by health care professionals to make millennials aware about the divergence between health and diet perceptions and health outcomes.

Table 2. Cross tabulation of diet and health perceptions and health Outcome

Perception		Health Outcome (%)			
	Underweight	Normal Weight	Overweight	Obese	Total
Diet perception (%)					
Somewhat or very unhealthy	0.35	2.97	4.00	6.90	14.22
Somewhat healthy	4.49	28.02	19.05	18.29	69.84
Very healthy	1.79	8.83	2.97	2.34	15.94
Total	6.63	39.82	26.02	27.54	100
Health perception					
Somewhat or very unhealthy	0.41	1.93	3.59	4.35	10.29
Somewhat healthy	4.00	23.60	17.46	19.25	64.32
Very healthy	2.21	14.29	4.97	3.93	25.40
Total	6.63	39.82	26.02	27.54	100

In our survey sample, 20.33% reported to have chronic illness themselves, 31.37% reported that somebody in the family have chronic illness, and 36.01% reported that somebody in the family lost life due to chronic illness. In 2012, about half of all U.S. adults (117 million people) had one or more chronic health condition [23]. Given that the median age for the study sample is 30 years, the fact that 20% is reported to have some kind of chronic illness is a matter of serious concern for health care providers and policy makers. Although relative to the overweight and obese levels, prevalence of chronic illness is low among the millennials, the divergence between the perceptions and health outcomes suggest that the level of chronic illness is likely to increase in the future.

It is important to note here that about 74% of those who reported to have chronic illness also have somebody in the family with chronic illness. The statistically significant correlation coefficient between the two was 0.46. As per the survey data, only 33% of those who reported to have chronic illness have normal weight (283 out of 1,448 or ~20% of the respondents) where as 5% is underweight, 24% is overweight, and 37% is obese. This finding suggest a strong association between chronic illness among the millennials and prevalence of overweight and obese. We also find that about 60% (12.37 out of 20.33%) of those who reported to have chronic illness condition for themselves perceive their diet to be somewhat healthy (Table 3). This again suggests the divergence between diet perceptions and health outcomes. It is important that health care professionals are aware of this divergence between perceptions and health outcomes and engage in outreach efforts to address it. These findings also suggest the potential for probiotics in addressing health concerns among the millennials.

Table 3. Cross tabulation of diet perception and prevalence of chronic illness

	Chronic illness (self)			Chronic illness for Family member			Loss of life in family due to chronic illness		
	Yes	No	Total	Yes	No	Total	Yes	No	Total
Diet perception (%)									
Somewhat or very unhealthy	4.28	10.03	14.31	5.70	8.71	14.41	6.56	7.76	14.32
Somewhat healthy	12.37	56.79	69.16	20.38	48.59	68.97	24.89	44.18	69.08
Very healthy	3.68	12.84	16.52	5.29	11.33	16.62	4.55	12.05	16.59
Total	20.33	79.67	100	31.37	68.63	100	36.01	63.99	100

Awareness and use of probiotics among the millennials

As per the survey data although 88.7% of survey respondents are aware of probiotics, only 46.52% have used it during the last 30 days prior to the survey period. It has to be noted here that in a 2008 survey by Research Opinion Corporation, only 15% of the people interviewed were familiar with the concept of probiotics [7]. However, in a 2015 study focusing on hospitalized patients, 73% of the 200 patients responded to the survey were familiar with the term probiotics and 53% of patients were consuming or had consumed probiotics [22]. Although results from our study that focuses on free-living millennials are not directly comparable to the 2015 study, overall these results suggest an increase in awareness and use of probiotics among the healthy and sub-healthy population in the U.S. The increased advertising and marketing efforts by probiotic companies that leverage on the results from the public and private sector R&D investments in probiotic research and the increased acceptance of probiotics by physicians in recent years might have contributed to the observed increase in awareness and use of probiotics [7, 16, 17]. In our study, 77.26% of the respondents expressed their intention to use probiotics in the future of which about 58% are current users of probiotics. It is also important to note here that 96.8% of current users expressed their willingness to use probiotics in future as well. These findings suggest that demand for probiotics is going to increase in the future.

For the categories based on perception of diet, awareness and the use are high among those who perceive their diet to be healthy; 62% and 32%, respectively. Awareness and use are low among those who perceive themselves to be unhealthy; 11.5% and 3.4%, respectively. Similarly, awareness and the use are the high among those who perceive themselves to be healthy; 56.3% and 28.5%, respectively, and low among those who perceive themselves to be unhealthy; 9.02% and 3.54%, respectively. Similar trends hold for future use of probiotics among the millennials, with most of the increase in future use stemming from the category of those who consider their diet and themselves to be healthy.

For health outcomes when taken individually, awareness and use are high among those who have normal weight; 35.42% and 20.65%, respectively relative to the underweight/overweight/obese categories. This finding confirms our earlier results regarding the disconnection between diet and health perceptions and health outcomes. The finding that probiotic use is high among healthy millennials suggest that probiotics can play an important role in overall health maintenance.

Although most of our survey respondents are aware of probiotics (88.7%), only about 52% of them consume it currently. To examine the reasons for non-use of probiotics, we have asked our respondents who do not use probiotics currently, to rank the importance of the following in their decision of not to use probiotics: income/price constraints, issues related to practicality (e.g. forget to use it regularly), lack of trust in food industry, not convinced about the benefits of probiotics, and overall good health status on a Likert scale of 1 to 5 where 1 is not important and 5 is very important. Additionally, for our analysis we categorized non-users into two categories; those who are aware of probiotics and those who are not aware of probiotics. For the former category, income/price constraints and the perception of good health status were the most dominant reasons (both with a mean value of 3.3) for not using probiotics. For those who are not aware of probiotics, perception of good health status (with mean value of 3.21) and not

convinced about the benefits of probiotics (with a mean value of 3.07) are the most factors in their decision making.

As reported in the literature on functional foods, these results underscore the importance of pricing considerations in marketing efforts for probiotics [12, 14]. Again, the importance of perceived health status in non-use decision is in line with our earlier finding that there is divergence between perceptions and health outcomes among the millennials. The study's finding may also imply that because of the perception that they are healthy many millennials may not see the need for using probiotics.

Drivers of probiotic use

As mentioned earlier, we have employed a probit model to examine the drivers of probiotic use. Summary statistics of variables included in the empirical model presented in Table 4 show that there are differences in the demographic and lifestyle characteristics of users and non-users of probiotics. It is clear from Table 4 that the current users of probiotics are older, have higher education levels, have employment, have higher income, are married, have children, exercise regularly, read food labels before purchase decisions, and have better health outcomes in terms of BMI.

Table 4. Summary of key variables included in the probit model on probiotic use

Variable	Probiotic Use	
	No	Yes
Age (years)	29.501 (4.815)	30.125(4.583)***
Sex (female)	0.504(0.500)	0.507(0.500)
Education		
High school/GRE/Vocational	0.531(0.499)	0.362 (0.481)***
Currently in college	0.101(0.302)	0.114(0.317)
4-year college degree or higher	0.368(0.482)	0.524(0.499)***
Employed	0.615(0.487)	0.767(0.423)***
Income ($)		
0-29,999	0.400(0.490)	0.219(0.414)***
30,000-59,999	0.351(0.478)	0.341(0.474)
60,000-99,999	0.173(0.378)	0.279(0.449)***
>100,000	0.076(0.266)	0.161(0.368)***
Married	0.381(0.486)	0.524(0.499)***
Have children	0.419(0.494)	0.527(0.499)***
Exercise regularly	0.526(0.499)	0.753(0.432)***
Read food labels	0.724(0.447)	0.924(0.266)***
Normal weight	0.356(0.479)	0.448(0.497)***
Family member has chronic health condition	0.309(0.462)	0.318(0.466)

Note: *** indicates that the difference in mean values of users and non-users are statistically significant at 1% level.

Since coefficients from the probit model gives the direction of effect and not the size effect (marginal effect), we report both coefficients and marginal effects of regression model at mean values in Table 5. Results of probit model presented in Table 5 shows that age, employment, and income have positive and statistically significant effect on probiotic use among the millennials in the U.S. Our analysis shows that those who only have high school education or diploma are less likely to use probiotics. As in the case of functional foods in general, the positive effect of income and negative effect of low level of education suggest the importance of pricing strategies in market development for probiotics [12, 14, 15].

As reported previously in the literature on functional foods [24], our results also show that participants who read the food labels are more likely to use probiotics compared with participants who do not read food labels. It is evident from Table 5 that those who exercise regularly and those who have normal weight are more likely to use probiotics than those who do not exercise regularly and those who do not have normal weight. Overall these results provide insights for marketing strategies and outreach efforts for probiotic industry stakeholders and health care providers.

Table 5. Results from probit model on use of probiotics by the millennials in the U.S.

Variable	Coefficient (SE)	Marginal Effect (SE)
Age (years)	0.02 (0.01)**	0.01 (0.00)**
Sex (female)	0.09 (0.08)	0.03 (0.03)
Education		
4-year college degree or higher	-0.18 (0.12)	-0.07 (0.04)
High school/GRE/Vocational	-0.21 (0.12)*	-0.07 (0.04)*
Employed	0.19 (0.08)**	0.07 (0.03)**
Income ($)		
30,000-59,999	0.13 (0.09)	0.05 (0.03)
60,000-99,999	0.19 (0.13)	0.07 (0.05)
>100,000	0.38 (0.14)***	0.13 (0.05)***
Married	0.12 (0.09)	0.04 (0.03)
Have children	0.13 (0.08)	0.05 (0.03)
Exercise regularly	0.38 (0.08)***	0.13 (0.03)***
Read food labels	0.76 (0.10)***	0.26 (0.03)***
Normal weight (predicted values)	1.23 (0.48)**	0.43 (0.17)**
Family member has chronic health condition	0.07 (0.07)	0.02 (0.03)
Constant	-2.36 (0.41)***	

Note: ***, **, and * indicates that the difference in mean values of users and non-users are statistically significant at 1%, 5%, and 10% levels. SE- indicates standard error.

Millennials' preferences for carriers of probiotics

In the survey we asked respondents (irrespective of whether they used or not used probiotics) to rank their preferences for the following carrier forms of probiotics: capsule, yogurt, shake, juice, and snack bar in a one to five Likert scale where one is strong non-preference and five is strong

preference. We have taken these career forms to cover a broad portfolio of probiotics currently available in the market. Our results show that yogurt (28.34%) and shake (23.58%) are the most preferred carriers of probiotics among the millennials, and capsule form is the least preferred one (16.43%). These preferences hold even when we analyze preferences for carrier forms based on the use status suggesting that irrespective of the use status, yogurt and shake are the most preferred carriers of probiotics among the millennials. As reported in the literature on functional foods, these results suggest the importance of carrier forms in consumer choices for probiotics [13, 14].

CONCLUSION

Findings from our study show that although majority of the millennials perceive their diet to be healthy and themselves to be healthy, in terms of body mass index, most of them are either overweight or obese. Findings from the study suggest that there is divergence between health and diet perceptions and actual health outcomes among the millennials. Although prevalence of chronic illness is low (about 20%) relative to the overweight and obese levels, due to the divergence in perceptions and health outcomes, it is an important issue of concern for healthcare providers and health policy makers.

The study finds that awareness about probiotics is high and use of probiotics is common among the millennials. Demographic factors such as age, employment, income, and education and life style characteristics such as exercising regularly and the habit of reading food labels are important factors in millennials' probiotic use decisions. Our analysis showed that almost all of the current users are likely to continue their use of probiotics in future and overall use rate is going to increase in the future. Because of the common use of probiotics by the millennials, probiotics with evidence on efficacy have huge potential in addressing public health concerns in the country. The study also shows that among the non-users, pricing constraints and the perception of good health status are the main reasons for not using probiotics. Irrespective of whether they are currently using probiotics or not, yogurt and shake are the most preferred carrier forms of probiotics among the millennials.

Overall, our study shows that millennials are already an important market for probiotics and there is substantial scope for expanding that market. Availability of probiotics that meet millennials' preferences and expectation might lead to increased consumption of probiotics by millennials with positive implication on public health, public expenditure on healthcare system, and the overall economy. The ability of probiotics to address public health concerns will also depend greatly on how health care providers and probiotic industry leverage these high levels of awareness and use among the millennials. It is important that health care providers tap into the higher level of awareness and use of probiotics among millennials to address health concerns faced by them. Findings from our study provide insights that are helpful for probiotics product and market development and outreach efforts that will result in increased use of probiotics among the millennials with positive implications for public health and overall economy.

Additionally, as millennials raise their children it is likely that their food habits and preferences termed as "millennial effect" will influence their children's diet pattern and overall health with long term implications for public health in the country. Since millennials represent

the decision-makers and parents of the citizens in future, an increased understanding about the characteristics of those millennials who use probiotics and the factors driving the use and non-use of probiotics will provide helpful insights for probiotic industry, health care providers, and policy makers to use probiotics as one of the pathways to address health concerns in the short and long term.

List of Abbreviations: U.S., United States; BMI, body mass index.

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Authors' Contributions: Deepthi Kolady and Joy Scaria designed the study. Deepthi Kolady had the primary responsibility of developing the survey instrument, survey design and sample selection, data collection, data analysis, and writing the manuscript. Kendra Kattelmann, Caleb Vukovich, and Joy Scaria helped with data collection and analysis. All authors read and approved the final version of the manuscript.

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