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Determinants of weekly raw milk use by at-home meal preparers in the USA: evidence from the 2014–2016 American Time Use Survey – Eating and Health Module

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Abstract

Objective: The number of states in the USA that allows sales of raw milk for human consumption has been trending upwards and reached thirty-eight in 2016. These legislative changes could encourage raw milk consumption. The current study examined the determinants of weekly raw milk use by at-home meal preparers in the USA.

Design: Using the 2014–2016 American Time Use Survey – Eating and Health Module, multivariate logit regressions and average marginal associations were estimated to examine how at-home meal preparer characteristics, time use and shopping choices, underlying health and the presence of at-risk individuals in households and raw milk legalisation status are associated with the probability an at-home meal preparer consumed or served raw milk during an average week.

Setting: USA.

Participants: At-home meal preparers aged 18 years and above.

Results: Estimated average marginal associations suggested younger at-home meal preparers, male at-home meal preparers, larger sized households and households located in non-metropolitan areas were more likely to use raw milk during an average week. Married households and households with a person aged 62 years or above were less likely to use raw milk. Variables indicating health characteristics of at-home meal preparers or the presence of an at-risk individual in the household were not statistically significant.

Conclusions: There are many government-sponsored information resources about the risks of raw milk currently available. Additional education may be needed to prevent illnesses from raw milk.

Keywords
Unpasteurised (raw) milk
food safety
foodborne illness

The numerous websites offering raw (unpasteurised) milk for sale make it clear that there are consumers who are making raw milk as part of their and their households diets. However, there is no current and statistically reliable information on their number or how best to describe them. Further, these consumers are a puzzle to the public health community, since raw milk consumers are rejecting what the public health community justifiably treats as one of its biggest successes in history – milk that is simultaneously nutritious and unlikely to cause illness. Pasteurisation of milk has long been recognised as a major contribution to the reduction in the incidence of infectious diseases. This progress on public health is at risk of being reversed as legal access to raw milk from cows, sheep or goats for human consumption is increasing. Figure 1 shows legal access in twenty-five states in 2009, increasing to thirty by 2012 and to thirty-eight by 2016, where purchasing options range from retail stores (thirteen states) to on farms or via cow-share agreements (twenty-five states)[1,2]. Clearly, there is ongoing pressure on policymakers to loosen restrictions on the sale of raw milk.

To our knowledge, the last examination of the determinants of raw milk consumption by US consumers was by Buzby *et al.*[3]. They examined how a variety of factors, including ethnicity, education, income and consuming other risky foods, were associated with the probability a consumer drank raw milk. They relied on FoodNet survey data administered in seven states during

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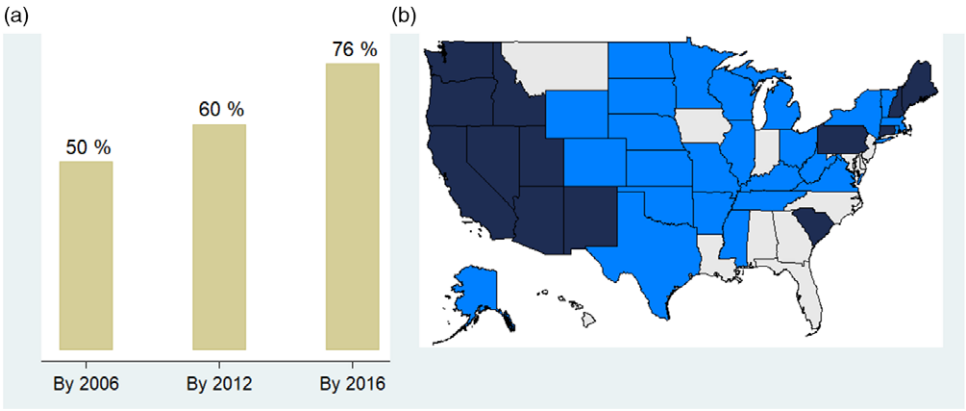

Fig. 1 (colour online) Legalisation of raw milk from cows, sheep or goats over time and in 2016. (a) Percentage of states with legal access to raw milk over time. (b) Legal access to raw milk by state as of 2016. ■, Retail; ■, on farm; □, sale not legal. By 2006, raw milk could be legally purchased in twenty-five states; by 2012, the number of states increased to thirty states; and by 2016, it increased to thirty-eight states. As of 2016, raw milk from cows, goats and sheep for human consumption could be legally purchased in retail stores in thirteen states (retail), on farms, or via cow-share agreements in twenty-five states (on farm) and was not legal from human consumption in twelve states (sale not legal).

three periods, 1998–1999, 2002–2003 and 2006–2007, where a randomly chosen person from each household was asked if in the past 7 d, raw milk was consumed.

To update and deepen our understanding of raw milk consumption by US consumers, the current study used the Bureau of Labor Statistics' 2014–2016 American Time Use Survey – Eating and Health Module (ATUS-EHM), a nationally administered and nationally representative survey designed to analyse time use and eating patterns, food safety practices and meal preparation, and grocery shopping and food adequacy[4]. ATUS-EHM was well designed for our purpose as respondents who answered as either being the person who usually prepares meals in the household or splits time equally with others were asked if they consumed or served raw milk in the previous 7 d. Consequently, raw milk consumption during the week was a question posed to those who are at-home meal preparers – those making food choices for households. Further, ATUS-EHM respondents have already participated in the Consumer Population Survey, so demographic information, like age, education, income and household size including number and age of children, labour force participation and some geographic information are available.

After pooling the 2014–2016 ATUS-EHM respondents who are at-home meal preparers aged 18 years and above, the current study estimated multivariate logit regressions to understand what factors are associated with changes in the probability that an at-home meal preparer consumed or served raw milk during an average week. Our analysis begins by including a wide class of individual and household characteristics that match and logically extend previous research. This baseline model examines to what extent meal planners' demographic, economic and household characteristics are associated with raw milk use. Afterwards, the baseline model is augmented in three ways: including variables describing at-home meal preparers' time use and shopping patterns, by health and foodborne illness risk factors and by changes in legal access to raw milk.

The model including variables describing at-home meal preparers' time use and shopping patterns tests whether time use and daily activities of meal planners who serve raw milk differ from those of meal planners who do not serve raw milk. Serving raw milk means that at-home meal preparers are shopping at different venues because major supermarkets do not offer raw milk even where state laws allow it.

Next, the model including health and foodborne illness risk factors tests whether raw milk choices depend on meal planners' health risks. The US Food and Drug Administration (FDA) warns that failing to pasteurise milk can pose serious health risks, particularly for people with weakened immune systems, pregnant women, children and older adults[5]. By highlighting that some consumers face especially high risks, the FDA and others have, in effect, pointed out that risks vary among consumers. The hypothesis that follows from this observation is that these varying risks lead to different demands for raw milk. The model examines whether the health of at-home meal preparers, the presence of children in the household and the presence of older adults in the household are correlated with raw milk use.

Finally, the model including variables identifying legal access to raw milk tests the influence of raw milk's geographically varying legal status on raw milk choices. If laws are enforced, it would be more costly to acquire raw milk in states that made raw milk sale illegal than in states where retail sales are legal. In effect, the model tests whether the geographically varying cost of acquiring raw milk is correlated with its use.

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Background

Pasteurisation of milk is a process of heating milk to kill bacteria and other micro-organisms that can cause illness in humans. It also kills spoilage bacteria, lengthening the shelf life of milk. The heating process is brief, longer at lower temperatures. In the USA, the specific temperatures and time duration are specified by the FDA in the *Grade 'A' Pasteurised Milk Ordinance* and apply to all interstate shipments of milk and milk products intended for direct human consumption[6]. Individual states can allow intra-state shipments of raw milk from cows, sheep or goats for human consumption.

The Federal government's perspective on raw milk consumption is unambiguously against the consumption of raw milk for any reason. The FDA states that pasteurisation is necessary to produce a safe product. Without pasteurisation, even the best dairy management practices, such as following a Hazard Analysis and Critical Control Point system, do not make raw milk safe to drink. In fact, the Centers for Disease Control and Prevention warns that even healthy animals raised in sanitary and humane conditions can still carry bacteria that can be harmful to humans, including *Brucella*, *Campylobacter*, *Cryptosporidium*, Shiga toxin-producing *Escherichia coli*, *Listeria monocytogenes* and *Salmonella,* nontyphoidal[7]. The severity of human illness can range from diarrhoea, stomach cramping and vomiting to kidney failure, paralysis and death.

Research has shown that illnesses and hospitalisations from raw milk do occur. From 1973 to 2012, researchers at the Centers for Disease Control and Prevention attributed at least 169 outbreaks to the consumption of raw milk, resulting in at least 3642 illnesses[1,2,8]. From 1993 to 2012, outbreaks attributed to the consumption of raw milk resulted in at least 144 hospitalisations[1,2]. Further, research has found that consumers of unpasteurised dairy products (milk and cheese), compared with consuming pasteurised dairy products, are 839 times more likely to experience a foodborne illness and forty-five times more likely to be hospitalised[9].

Numerous health claims have been made for consuming raw milk. These claims range from raw milk as a cure to lactose intolerance to the nutritional superiority and safety of raw milk compared with pasteurised milk. However, the FDA has studied each of the claims from a scientific perspective and concluded that there is no merit in any of the claims[10]. Raw milk does not cure lactose intolerance, asthma or allergies. It is not more effective in preventing osteoporosis nor is it nutritionally superior to pasteurised milk. It is not an immune system-building food, and there are no beneficial bacteria in raw milk for gastrointestinal health. It does not contain natural antimicrobial components that make raw milk safe nor does it contain nisin for pathogen inhibition.

Similarly, the academic literature has reviewed numerous dietary and health claims of raw milk dating back to at least 1984[11]. Findings suggest that the effect of pasteurisation of milk on vitamins, like B_5, B_6, B_7, B_{12}, A, D and E is small to negligible, and pasteurisation does not significantly affect the bioavailability of Ca[12]. Research fails to support an association between raw milk consumption and a reduced risk of cancer, and no significant association exists between raw milk consumption and lactose intolerance[13].

Materials and methods

Data

The ATUS is a Bureau of Labor Statistics (BLS) survey with a stated purpose of developing nationally representative estimates of how people aged 15 years or older spend their time[14]. Individuals are sampled from the panel of households that have completed their eighth and final month of interviews for the Consumer Population Survey. Those who participate are then interviewed one time about how they spend their time from 04.00 hours the previous day to 04.00 hours of the interview day as well as answer other questions that recall events within the past 7 or 30 d.

The 2014–2016 ATUS-EHM featured new questions on consumers' choices in selecting or preparing certain foods and their food safety actions. Central to the current paper are two questions: one on meal preparation and one on raw milk. Specifically, respondents are asked: 'Are you the person who usually prepares the meals in your household?' Afterwards, respondents who answered 'yes' or answered 'split it equally with other household member(s)' were asked about raw milk consumption: 'In the last 7 days, did you drink or serve unpasteurized or raw milk?' Consequently, only those who were at-home meal preparers were asked whether they served or drank raw milk during the week. Hence, the ATUS-EHM is suitable for examining what influences an at-home meal preparer's decision to consume or serve raw milk in the previous 7 d.

For simplicity, the usual meal preparers or those who split the task are here referred to as at-home *meal preparers*. Further, *raw milk use* here refers to the act of consuming or serving raw (unpasteurised) milk in the previous 7 d. Given the time frame and following convention, responses of consuming or serving raw milk were used to estimate and examine raw milk use by US at-home meal preparers during an average week[15].

Pooling the 2014–2016 ATUS-EHM data resulted in 23 077 at-home meal preparers, aged 18 years and above, and of which, 23 031 respondents provided non-missing answers to raw milk use in the previous 7 d: 431 used raw milk and 22 600 did not use raw milk. To conduct conventional hypothesis tests, variance estimates need to account for the survey's complex design. BLS recommends calculating variances using replicate weights – variables denoted WGT1–WGT160. BLS also recommends setting a Fay coefficient set equal to 0·5 and to use balanced

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repeated replication to correctly estimate SE[14,16]. BLS further recommends dividing the ATUS-EHM final weight by the total number of days across all years for annually pooled samples[17].

Descriptive variables

The ATUS-EHM contains responses that can be used to examine standard descriptive characteristics of at-home meal preparers and their households. It also contains unique responses that can be used to examine time use and shopping behaviours as well as the presence of populations at-risk of foodborne illness.

Conventional categories to describe at-home meal preparers include gender, relationship status, age, ethnicity, formal education and employment status. Gender was defined using an indicator for male at-home meal preparers. Relationship status was defined using an indicator for married at-home meal preparers. Age was defined using a set of indicators: one for at-home meal prepares aged 18–34 years, a second for those aged 35–59 years and a third for those aged 60 years and above. Ethnicity was defined by an indicator for at-home meal preparers who are either Spanish, Hispanic or Latino[18]. Formal education was defined by a set of indicators: for at-home meal preparers with at most a high school diploma, an indicator for those with at most an associate's degree and an indicator for those with at least a bachelor's degree. Employment status was defined by three mutually exclusive categories: an indicator for employed, an indicator for unemployed and an indicator for not in the labour force.

Conventional categories to describe the households of at-home meal preparers consisted of household size, geographic location and poverty status. Household size was defined by the total number of people in the home as reported by an at-home meal preparer. Geographic location was defined by an indicator for at-home meal preparers living in non-metropolitan areas (the closest available proxy for living on a farm or rural community). Poverty status was defined by an indicator for household incomes exceeding 185 % of the Federal poverty line, adjusted for household size.

The ATUS-EHM contains unique data on time spent on food shopping, preparing meals and eating. Specifically, the ATUS-EHM asks about how many minutes in the last 24 h you spent on grocery shopping, how many minutes in the last 24 h you spent on preparing food, including cleanup and how many minutes in the last 24 h you spent on eating as a primary activity, which includes eating and drinking, eating and drinking not elsewhere classified (used by BLS to assess the completeness of response categories) and eating and drinking as part of a job[15]. Also, the ATUS-EHM asked respondents what type of store they used for the majority of their groceries. Answer choices were grocery store, super centre, warehouse club, drugstore or convenience store or some other place. To describe the food store preferences of at-home meal preparers, the current study defined an indicator for grocery store, an indicator for super centre or warehouse club and an indicator for drugstore, convenience store or some other place.

The ATUS-EHM also contains unique data relevant to physical health. The ATUS-EHM asked respondents to rank their physical health on a scale of poor, fair, good, very good or excellent. Additionally, respondent's height and weight are available, so BMI can be computed. To describe the health characteristics of at-home meal preparers, the current study included an indicator for at-home meal preparers who rank their physical health as poor and a set of indicators for at-home meal preparers with BMI between 25 or more (at least overweight), 30–35 (class 1 obesity), 35–40 (class 2 obesity) and 40 or more (class 3 obesity)[19].

Last, ATUS-EHM can be used to examine possible raw milk consumption by at-risk populations, specifically children and the elderly. For the presence of children, the ATUS-EHM asks about the presence of children in the household, either children under the age of 18 years who may or may not be related to the respondent or biological children, step children or adopted children who reside in the respondent's home or in another home. An indicator for the presence of at least one child in the household was constructed. For the presence of elderly, the respondent is asked to report the age of each person in the household. An indicator for at least one person who was not an at-home meal preparer being aged 62 years or above was constructed.

Regression framework

To model the decision-making process of at-home meal preparers to drink raw milk, of interest is the quantity of raw milk served or consumed by an at-home meal preparer during an average week, denoted by q^*, which is assumed to depend on meal preparer and household characteristics, X, a vector of parameters, β, and an error term, ε:

$$q^* = X\beta + \varepsilon. \tag{1}$$

However, q^* is unobserved. What is observed is an indicator equal to 1 if an at-home meal preparer served or consumed raw milk and zero otherwise:

$$q = \begin{cases} 1 \text{ if } q* > 0 \\ 0 \text{ if } q* = 0. \end{cases} \tag{2}$$

Using (2), the probability of observing an at-home meal preparer serving of consuming raw milk reduces to

$$\Pr(q = 1|X) = F(X\beta), \tag{3}$$

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where $F(\cdot)$ is the cumulative distribution function of $-\varepsilon$. Under the logistic distribution, (3) simplifies to the logit model:

$$\Pr(q = 1|X) = \frac{\exp(X\beta)}{1 + \exp(X\beta)}. \quad (4)$$

Parameters for our logit model were estimated in Stata® 14. The resulting logit regression estimates and SE were then used to estimate average marginal associations. For discrete characteristics, the estimated average marginal associations is the average in the difference between two predicted probabilities: the probability that each at-home meal preparer in the sample affirms the discrete characteristic and the probability that each at-home meal preparer in the sample does not affirm the discrete characteristic. This difference, measured in percentage point units, indicates sign and magnitude. These average marginal associations were estimated using factor variables in Stata®[20]. For a continuous characteristic, like household size, the estimated average marginal association measures the average in the change in the predicted probability from an incremental increase in the number of people in the household, holding all other model factors fixed at the observed values from the data. This difference is again measured in percentage point units and indicates sign and magnitude.

The baseline model examined standard variables for at-home meal preparers and their household to test whether socio-demographic characteristics are correlated with raw milk use. The included characteristics mimic those examined by the previous literature and parsimoniously parallel our descriptive variables[3]. Specifically, the set of at-home meal preparer characteristics included an indicator for gender, an indicator for married *v.* not married, an indicator for younger than 35 years *v.* 35 years and older, an indicator for ethnicity (Spanish, Hispanic or Latino *v.* all other), an education indicator for at most a high school graduate *v.* at least some college or beyond and an indicator for not in the labour force *v.* employed or unemployed. The set of household characteristics included the total number of people in the household, an indicator for a household located in a non-metropolitan area *v.* a metropolitan area and an indicator for a household with a total income below 185 % of the federal poverty line, adjusted for household size. Lastly, given the upwards trend in raw milk legalisation, year indicators were included to control for possible trend in raw milk use: an indicator for 2015 *v.* 2014 and an indicator for 2016 *v.* 2014.

For the first extension of the demographic model into time use, the model included indicators for an at-home meal preparer who spends over 30 min on grocery shopping during an average day, an indicator for spending over 90 min on eating during an average day and an indicator for spending over 120 min on food preparation and cleaning during an average day. For shopping preference, the current study included an indicator if an at-home meal preparer uses a drugstore, convenience store or some other place for the majority of grocery shopping needs compared with using a grocery store, super centre or warehouse club.

The second extension examined if health characteristics of at-home meal preparers and the number of at-risk household members, like those who are immunocompromised, children or elderly, are correlated with raw milk use. While data on the extent to which at-home meal preparers were immunocompromised are not available in the ATUS-EHM, respondents were asked to rank their physical health on a scale of poor to excellent. Additionally, BMI can be computed as an additional physical health proxy. Hence, an indicator was constructed for at-home meal preparers who rank their physical health as poor and indicators for at-home meal preparers with BMI between 25 and 30 (overweight) and 30 or more (obese)[19]. Also, an indicator for the presence of at least one child in the household and an indicator for the presence of at least one person who was not an at-home meal preparer aged 62 years or above were constructed.

Our third set of tests examined if state-level legalisation status of raw milk for human consumption are correlated with raw milk use. To categorise legalisation status, supplementary data on annual state legalisation status of raw milk from cows were used to construct indicators for states where raw milk from cows can be legally purchased via retail stores or farmers' markets and for states where raw milk from cows can be legally purchased on farms only or by cow-share agreements[21]. The omitted comparison group includes all states where raw milk from cows is illegal to purchase for human consumption.

Throughout all three tests, the at-home meal preparer and household demographic variables continued to be included in case of any correlation between these baseline controls, time use, health characteristics or legalisation access and raw milk use. Consequently, the point estimates and average marginal associations for demographics can be assessed for robustness after including additional variables to the baseline model. Lastly, lacking a valid exclusion restriction that affects the decision to be an at-home meal preparer while not directly affecting raw milk use limits the population under discussion to US at-home meal preparers as opposed to the general US population aged 18 years and above.

Results

Population-weighted statistics

Descriptive statistics of at-home meal preparers are shown in Table 1 for characteristics that describe at-home meal preparers, the household, the time use and shopping choices of at-home meal preparers and notable at-risk populations. From 2014 to 2016, 14 % of at-home meal preparers are Hispanic, 35 % are male, 52 % are married and 45 % are between the ages of 35 and 59. For formal

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Table 1 Descriptive statistics of US at-home meal preparers and raw milk use

	Category	Variable	Average	SE
Meal preparer characteristics	Gender	Male	0·35	0·003
	Relationship status	Married	0·52	0·004
	Age (years)	18–34	0·26	0·003
		35–59	0·45	0·002
		60 and over	0·29	0·002
	Ethnicity	Hispanic	0·14	0·002
	Education	High school graduate	0·39	0·003
		Associate degree	0·27	0·004
		BA or better	0·34	0·004
	Employment status	Employed	0·60	0·004
		Unemployed	0·03	0·002
		Not in labour force	0·37	0·004
Household characteristics	Household size	Total number of people	2·62	0·012
	Household location	Non-metro	0·15	0·004
	Poverty status	Below 185 %	0·37	0·004
Time use and shopping	Time use (min/d)	Shopping	8	0·183
		Food preparation	48	0·474
		Eating	64	0·400
	Usual store	Grocery	0·69	0·004
		Super centre or club	0·28	0·004
		Convenience or other	0·03	0·002
At-risk populations	BMI (kg/m^2)	25 or more (overweight, obese)	0·65	0·004
		30–35 (class 1)	0·18	0·003
		35–40 (class 2)	0·07	0·002
		40 or more (class 3)	0·05	0·002
	Physical health	Poor	0·04	0·002
	Children present	Any present	0·33	0·003
		Youngest under age 5	0·46	0·007
	Elderly present	Aged 62 years or above	0·19	0·003
Raw milk use	Weekly raw milk use	Drinks or serves raw milk	0·02	0·001

Population-weighted proportions and SE (averages and SE reported for time use in min/d) using the American Time Use Survey – Eating and Health Module 2014–2016.

education attainment, 39 % of at-home meal preparers have at most a high school diploma, 27 % have at most an associate's degree and 34 % have at least a bachelor's degree. For general employment status, 3 % of at-home meal preparers are unemployed, 37 % are not in the labour force and 60 % are employed. The total household size averages to 2·6 people. For household location, 15 % of at-home meal preparers are located in non-metropolitan areas. On the basis of pre-tax income, 37 % of at-home meal preparers have a household income level that falls below 185 % of the federal poverty level corrected for household size.

During an average day, at-home meal preparers spent about 8 min on grocery shopping. They spent about 48 min towards food preparation, including cleaning, and spent about 64 min on eating. When shopping, 69 % of at-home meal preparers used grocery stores for their food purchases, 28 % used super centres or warehouse clubs and 3 % used drug, convenience or other stores.

Based on self-reported height and weight, 65 % of at-home meal preparers are either overweight or obese. By increasing levels of obesity, 18 % of at-home meal preparers are class 1 obese, 7 % are class 2 obese and 5 % are class 3 obese. For physical health, 4 % of at-home meal preparers self-rank their physical health as poor. For the presence of any children at any age, 33 % of at-home meal preparers have at least one household or own child and 46 % have a household child under the age of 5. For the presence of an elderly household member who is not the respondent, 19 % of at-home meal preparers live with a person aged 62 years or older.

Lastly in Table 1, 2 % of at-home meal preparers used raw milk during an average week. Or equivalently, 3·2 million people (1·3 % of the US population aged 18 years or above) consumed or served raw milk during the week from 2014 to 2016[22].

How demographic characteristics are correlated with raw milk use

Table 2 provides logit regression estimates where the dependent variable is an indicator if an at-home meal preparer served or consumed raw milk in the previous week. Independent variables are at-home meal preparer characteristics, household characteristics and year indicator variables. The point estimates in column 3 indicate sign (i.e. positively related or negatively related) but not magnitude. Column 4 provides the estimated average marginal association of the estimates in column 3, thereby providing both sign and magnitude.

For statistically significant at-home meal preparer characteristics from Table 2, column 4, male at-home meal

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Table 2 Logit estimates for the determinants of serving or consuming raw milk by US at-home meal preparers†

	1	2	3	4
	Meal preparer characteristics	Including household characteristics	Including year indicators	Marginal associations
At-home meal preparer				
Male				
Estimate	0·223	0·284**	0·288**	0·58*
SE	0·137	0·141	0·141	0·30
Married				
Estimate	–0·259*	–0·396**	–0·405**	–0·79**
SE	0·140	0·164	0·163	0·32
Aged 34 years or below				
Estimate	0·467***	0·353**	0·353**	0·74**
SE	0·154	0·150	0·150	0·35
Hispanic				
Estimate	0·162	0·083	0·067	0·13
SE	0·182	0·186	0·186	0·38
High school graduate				
Estimate	–0·049	–0·182	–0·175	–0·34
SE	0·126	0·140	0·142	0·27
Not in labour force				
Estimate	0·274*	0·246	0·248	0·50
SE	0·153	0·156	0·157	0·33
Household				
Total people in home				
Estimate		0·141***	0·147***	0·28***
SE		0·046	0·046	0·10
Non-metro location				
Estimate		0·465***	0·467***	1·06**
SE		0·169	0·170	0·45
Income below 185 %				
Poverty line				
Estimate		0·235	0·230	0·45
SE		0·166	0·167	0·33
Year indicators				
Year 2015				
Estimate			–0·563***	–0·97***
SE			0·192	0·30
Year 2016				
Estimate			0·194	0·38
SE			0·160	0·32
n	23 031	22 825	22 825	22 825

†Logit regression estimates are provided in columns 1–3 and indicate sign but not magnitude. Average marginal associations, measured in percentage point units, are provided in column 4, are based on the logit regression estimates in column 3 and indicate sign and magnitude. SE are calculated using balanced repeated replication with replicate weights, WGT1–WGT160, after setting the Fay coefficient equal to 0·5[14,16]. Sample weighting was done using the variable (EUFINLWGT) Bureau of Labor Statistics calculates for that purpose, divided by the total number of days in our sample[17]. Lastly, Hispanic is defined as a respondent who is either Spanish, Hispanic or Latino[18].
*$P < 0·10$, **$P < 0·05$, ***$P < 0·01$.

preparers are more likely to use raw milk in an average week by 0·6 percentage points compared with female at-home meal preparers. Married at-home meal preparers are less likely to use raw milk in an average week by 0·8 percentage points compared with non-married at-home meal preparers. At-home meal preparers younger than 35 years are 0·7 percentage points more likely to use raw milk compared with older at-home meal preparers. For statistically significant household characteristics, at-home meal preparers living in non-metropolitan areas are 1 percentage points more likely to use raw milk compared with those living in metropolitan areas. For statistically significant household characteristics, the probability that an at-home meal preparer uses raw milk increases by 0·3 percentage points as the number of people in the household increases.

How shopping and time use are correlated with raw milk use

The results for how time use towards primary eating, food shopping or meal preparation during an average day is associated with raw milk use are presented in Table 3.

The point estimates in column 1 indicate that time use spent during an average day on shopping, eating or

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Table 3 Logit estimates examining if time use and shopping choices alter raw milk use†

	1	2	3	4
	Added time use	Added shopping choice	Added both	Marginal associations
Baseline controls				
Male				
Estimate	0·288**	0·300*	0·308**	0·61*
SE	0·141	0·154	0·155	0·33
Married				
Estimate	–0·406**	–0·371*	–0·366*	–0·69*
SE	0·163	0·200	0·199	0·38
Aged 34 years or below				
Estimate	0·353**	0·264	0·264	0·53
SE	0·150	0·162	0·162	0·35
Hispanic				
Estimate	0·067	0·042	0·044	0·09
SE	0·186	0·198	0·198	0·38
High school graduate				
Estimate	–0·175	–0·049	–0·056	–0·11
SE	0·140	0·150	0·148	0·28
Not in labour force				
Estimate	0·247	0·131	0·131	0·25
SE	0·157	0·162	0·162	0·32
Total people in home				
Estimate	0·147***	0·137**	0·133**	0·25**
SE	0·047	0·056	0·056	0·11
Non-metro location				
Estimate	0·467***	0·320**	0·317**	0·67*
SE	0·170	0·156	0·156	0·36
Income below 185 % Poverty line				
Estimate	0·230	0·193	0·186	0·36
SE	0·168	0·184	0·185	0·36
Year 2015				
Estimate	–0·563***	–0·527**	–0·527**	–0·89***
SE	0·191	0·206	0·204	0·33
Year 2016				
Estimate	0·194	0·073	0·072	0·14
SE	0·159	0·164	0·163	0·31
Time use (average day)				
Over 30 min shopping				
Estimate	–0·025		0·012	0·02
SE	0·271		0·290	0·55
Over 90 min eating				
Estimate	0·023		–0·170	–0·30
SE	0·167		0·161	0·28
Over 120 min preparing meals				
Estimate	0·005		0·073	0·14
SE	0·209		0·218	0·44
Shopping choice				
Convenience store or other				
Estimate		0·687**	0·692**	1·79*
SE		0·284	0·284	0·97
n	22 825	20 796	20 796	20 796

†Logit regression estimates are provided in columns 1–3 and indicate sign but not magnitude. Average marginal associations, measured in percentage point units, are provided in column 4, are based on the logit regression estimates in column 3 and indicate sign and magnitude. SE are calculated using balanced repeated replication with replicate weights, WGT1–WGT160, after setting the Fay coefficient equal to 0·5.[14,16] Sample weighting was done using the variable (EUFINLWGT) Bureau of Labor Statistics calculates for that purpose, divided by the total number of days in our sample[17]. Lastly, grocery shopping is activity 070101; primary eating includes the following activities: eating and drinking (110101 and 110199), eating and drinking not elsewhere classified (119999) and eating and drinking as part of job (050202); and preparing meals, ding cleanup, includes activities 020201, 020202 and 020203[15].
*$P < 0·10$, **$P < 0·05$, ***$P < 0·01$.

preparing food do not statistically alter an at-home meal preparer's use of raw milk during an average week. The point estimate in column 2 indicates that at-home meal preparers who shop at a convenience store or other store compared with grocery, warehouse or club stores are more likely to use raw milk. Column 3 illustrates that this statistically significant finding is not sensitive to the inclusion of our time use indicators. Column 4 provides the estimated average marginal associations of the regression estimates in column 3. Notably, at-home meal preparers who use convenience stores or other stores for addressing typical grocery needs are nearly 2 percentage points more likely to use raw milk compared with those who use grocery stores, warehouse stores or club stores.

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Table 4 Logit estimate examining if physical health and presence of at-risk individuals in households alter raw milk use†

	1	2	3	4	5
	Meal preparer health	Children present	Elderly present	Added all	Marginal associations
Baseline controls					
Male					
Estimate	0·239	0·271*	0·286**	0·204	0·40
SE	0·150	0·142	0·141	0·152	0·31
Married					
Estimate	–0·443**	–0·387**	–0·358**	–0·327*	–0·62*
SE	0·171	0·160	0·171	0·180	0·35
Aged 34 years or below					
Estimate	0·359**	0·357**	0·328**	0·321**	0·66*
SE	0·161	0·152	0·148	0·159	0·36
Hispanic					
Estimate	0·023	0·077	0·061	0·026	0·05
SE	0·192	0·184	0·187	0·191	0·37
High school Graduate					
Estimate	–0·219	–0·174	–0·164	–0·197	–0·37
SE	0·146	0·140	0·141	0·143	0·27
Not in labour force					
Estimate	0·225	0·223	0·290*	0·259	0·51
SE	0·169	0·156	0·160	0·170	0·35
Total People in Home					
Estimate	0·139***	0·186***	0·145***	0·198***	0·38***
SE	0·049	0·060	0·047	0·063	0·13
Non-metro location					
Estimate	0·459**	0·477***	0·468***	0·477***	1·07**
SE	0·182	0·170	0·169	0·179	0·47
Income below 185 % Poverty line					
Estimate	0·270	0·247	0·220	0·280	0·55
SE	0·177	0·168	0·220	0·177	0·36
Year 2015					
Estimate	–0·561***	–0·566***	–0·564***	–0·568***	–0·97***
SE	0·202	0·193	0·192	0·204	0·32
Year 2016					
Estimate	0·165	0·190	0·192	0·153	0·30
SE	0·169	0·160	0·159	0·169	0·33
Health controls					
Poor physical health					
Estimate	0·149			0·138	0·28
SE	0·304			0·308	0·66
BMI (25, 30)					
Estimate	0·248			0·267	0·53
SE	0·177			0·177	0·37
BMI 30 and beyond					
Estimate	0·016			0·029	0·06
SE	0·182			0·180	0·35
At-risk populations					
Children present					
Estimate		–0·226		–0·365	–0·67
SE		0·220		0·241	0·45
Elderly Present (62+)					
Estimate			–0·336	–0·613**	–0·97**
SE			0·217	0·246	0·31
n	21 478	22 825	22 825	21 478	21 478

†Logit regression estimates are provided in columns 1–4 and indicate sign but not magnitude. Average marginal associations, measured in percentage point units, are provided in column 5, are based on the logit regression estimates in column 4 and indicate sign and magnitude. SE are calculated using balanced repeated replication with replicate weights, WGT1–WGT160, after setting the Fay coefficient equal to 0·5[14,16]. Sample weighting was done using the variable (EUFINLWGT) Bureau of Labor Statistics calculates for that purpose, divided by the total number of days in our sample[17]. BMI is a person's weight in kilograms divided by the square of height in metres. For adults, a BMI <25 defines the normal weight range; a BMI greater than 25 but <30 defines the overweight range; a BMI of at least 30 defines the obese range[19]. Children present is defined as the presence of household children (those under the age of 18 and may or may not be related to the respondent) or own children (biological, step- or adopted-children, but not foster children, that reside in the meal preparer's home or in another home)[18].
*$P < 0·10$, **$P < 0·05$, ***$P < 0·01$.

Generally, our remaining estimated average marginal associations remain comparable with our previous marginal associations in Table 2. Some have slightly declined in absolute value, notably at-home meal preparers in non-metropolitan areas are 0·7 percentage points more likely to use raw milk compared with those living in metropolitan areas.

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Table 5 Logit estimate examining if state-level legal status alters raw milk use†

	1	2
	Adding legal status	Marginal associations
Baseline controls		
Male		
Estimate	0·290**	0·59*
SE	0·140	0·30
Married		
Estimate	−0·404**	−0·79**
SE	0·163	0·32
Aged 34 years or below		
Estimate	0·360**	0·75**
SE	0·150	0·35
Hispanic		
Estimate	0·052	0·10
SE	0·184	0·37
H.S. Graduate		
Estimate	−0·170	−0·33
SE	0·142	0·27
Not in labour force		
Estimate	0·246	0·49
SE	0·157	0·33
Total people in home		
Estimate	0·146***	0·28***
SE	0·047	0·10
Non-metro location		
Estimate	0·487***	1·11**
SE	0·170	0·45
Income below 185 % Poverty line		
Estimate	0·226	0·45
SE	0·168	0·34
Year 2015		
Estimate	−0·561***	−0·97***
SE	0·192	0·30
Year 2016		
Estimate	0·198	0·39
SE	0·159	0·32
Legal status		
Retail or farmers market		
Estimate	0·058	0·11
SE	0·176	0·35
On-farm or cow-share		
Estimate	−0·132	−0·26
SE	0·146	0·29
n	22 825	22 825

†Logit regression estimates are provided in column 1 and indicate sign but not magnitude. Average marginal associations, measured in percentage point units, are provided in column 2, are based on the logit regression estimates in column 1, and indicate sign and magnitude. SE in parentheses and were calculated using balanced repeated replication with replicate weights, WGT1–WGT160, and setting the Fay coefficient set equal to 0·5[14,16]. Sample weighting was done using the variable (EUFINLWGT) Bureau of Labor Statistics calculates for that purpose, divided by the total number of days in our sample[17]. These results used supplemental data on the annual state legalisation status of raw milk from cows[20]. *$P < 0·10$, **$P < 0·05$, ***$P < 0·01$.

How physical health and at-risk populations are correlated with raw milk use

The results on how physical health and the presence of at-risk populations are correlated with raw milk use are presented in Table 4. The results in column 1 indicate that at-home meal preparers in poor physical health or with high body masses are more likely to use raw milk. However, these point estimates are not statistically significant.

The results in column 2 indicate that having at least one child present is negatively associated with raw milk use by at-home meal preparers; but, this point estimate is not statistically significant. The results in column 3 indicate that having an elderly member present is negatively associated with raw milk use by at-home meal preparers; but, this point estimate is not statistically significant. After including all at-risk regressors, having an elderly member present in the household did statistically reduce the probability that an at-home meal preparer uses raw milk. The estimated average marginal associations are shown in column 5 and indicate that an elderly household member reduces the probability that an at-home meal preparer uses raw milk by nearly 1 percentage point compared with those not living with an elderly household member.

How legal status is correlated with raw milk use

The results on how the legal status of raw milk for human consumption is correlated with raw milk use are given in Table 5.

The results in column 1 reveal the importance of legal retail sales of raw milk from cows relative to not being legal for human consumption. Legal retail sales are positively associated with raw milk use by at-home meal preparers but not statistically significant. On farm or cow-share sales of raw milk are negatively associated with raw milk use but again are not statistically significant. Column 2 provides the estimated average marginal associations of the regression estimates in column 1. These estimated average marginal associations remain comparable with our previous marginal associations in Table 2.

Discussion

In contrast to Buzby *et al.*[3], results here show statistical evidence that age, area of residence and gender influence raw milk use by at-home meal preparers. Also in contrast, there is no statistical evidence that ethnicity, low education levels or low income influence raw milk use. Similar to Buzby *et al.*[3], the current study found no statistical association between at-home meal preparer use of raw milk and their states' legal status on consuming raw milk. However, the current study did find evidence that store preferences for groceries do influence the propensity of raw milk use by at-home meal preparers.

Differences in raw milk consumption likely exist between farm and city communities. Notably, Oliver *et al.*[23] cite estimates of raw milk usage by farm families and farm employees range from 35 to 60 %, well exceeding the population average that ranges from 2 to 4 %[24]. Reasons for relatively higher raw milk use by those living in farm communities may include a belief among farmers that it is risk-free, better quality, cheaper or simply more convenient[25]. While the current study does not measure or estimate the extent to which farm families are drinking raw milk during an average week, the current study did

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find statistical evidence that at-home meal preparers living in non-metropolitan areas are relatively more likely to use raw milk during an average week.

The food safety community has actively discouraged raw milk use and has focused particular attention on consumption by children and the elderly. The American Academy of Pediatrics state that only pasteurised milk and milk-based products should be consumed by pregnant women, infants and children[26]. While the current study does not measure or estimate the extent to which children are drinking raw milk during an average week, the current study failed to find a statistical association between the presence of children in the household and raw milk use by at-home meal preparers during an average week. This finding would not be reassuring to the public health community as it suggests that at-home meal preparers generally have the same number of children in their households as those who do not drink raw milk. Further, the size of this sub-population is non-trivial. That is, of raw milk drinking at-home meal preparers, 36 % or 1·1 million live with at least one child[22].

Similarly, the current study cannot measure or estimate the quantity or frequency with which elderly household members are drinking raw milk during an average week; but the current study did find statistical evidence that at-home meal preparers with a household member aged 62 years or older were less likely to use raw milk during an average week. However, controlling for the presence of children and elderly household members, the current study did find that larger sized households increase the probability that an at-home meal preparer drinks or serves raw milk during a typical week. Thus, potential consumption of raw milk by other members of the household remains a possibility.

Government health and safety officials, as well as the food safety community, offer guidance on reducing the likelihood of foodborne illness. For raw milk, both the FDA and the Centers for Disease Control and Prevention provide warnings and detailed assessments and unequivocally advise people to avoid it. Results here provide additional information about the characteristics of current raw milk consumers. This information might be helpful to policymakers' work to inform the public about the risks of raw milk consumption.

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