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The Influence of Time Use, Risk Factors and Occupation on Meal Preparers' Use of Food Thermometers

ABSTRACT

This study uses the 2014–2016 Eating and Health Module from the American Time Use Survey to examine factors associated with thermometer use by at-home meal preparers. It also examines the relationship between employment of meal preparers in foodservice and food thermometer use at home. Overall, 14% of at-home meal preparers use a food thermometer during a typical week when preparing meals that require temperature verification. Logit regression estimates indicate that male meal preparers use thermometers more than females do, married preparers use thermometers more than unmarried at-home meal preparers do, young adults (age 18–34) use thermometers more than older adults do, non-Hispanic meal preparers use thermometers more than Hispanic meal preparers do, and meal preparers who spend over 2 hours on daily food preparation use thermometers more than those who spend less time on food preparation and meal preparers in larger households are more likely to use food thermometers than those in smaller households, and meal preparers who judged themselves to be in poor physical health were less likely than others to use a food thermometer. Lastly, thermometer usage was higher for meal preparers working in food service-related jobs than for others, although more than three-quarters of these food service workers did not use a thermometer when preparing at-home meals that require temperature verification.

INTRODUCTION

Federal agencies' advice about safe temperatures is unequivocal: it is based on the fact that food cooked until it reaches the thermometer-verified temperature officials recommend is considered safe, and food that is cooked without the use of a thermometer to verify internal temperature is not considered safe *(7)*. Given the low time and effort-cost of following the advice, along with the substantial health risks incurred by failing to follow it, one would be tempted to hypothesize that thermometer use is commonplace. However, the existing literature suggests otherwise.

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Recently, Feng and Bruhn *(6)* searched the scientific literature to identify studies of consumers' and food workers' knowledge, attitudes, and behaviors regarding food thermometer use. The review generated 85 articles, which were analyzed in detail. The various studies indicate that consumers mostly do not use thermometers and do not know that observable characteristics of food being cooked are unreliable indicators of safety. The studies also collectively point to compliance being quite low even among food service workers.

Notably, Feng and Bruhn *(6)* highlighted results from the U.S. Food and Drug Administration's (FDA) 2006, 2010, and 2016 Food Safety Survey, which is designed to be representative of English- or Spanish-speaking adults in the United States. The surveys showed that thermometer use had not increased over time and, for preparation of some types of meals, is best characterized as an unusual practice. Lando et al. *(15)*, reporting results for the 2016 survey, found that 67 percent of households owned a food thermometer. They asked how often those who owned thermometers use them for various types of meat. The highest percentage of thermometer owners reported always using the thermometer for roasts (38 percent), with lower percentages for chicken parts (19 percent) and hamburgers (10 percent).

There are limits to the information the FDA Food Safety Survey provides. It does not ask respondents to report their occupation, so it cannot be used to address questions about the food safety behavior of food service workers. It likely lacks statistical power to determine significant differences in thermometer use in cooking hamburgers across multiple demographic cross-tabulations, such as thermometer use by gender, education, and marital status.

The objective of this study was to examine the extent and determinants of thermometer use among at-home meal preparers who prepare meals that require temperature verification. The Bureau of Labor Statistics' 2014–2016 American Time Use Survey – Eating and Health Module (ATUS-EHM), a nationally-administered and nationally-representative survey, specifically asks whether a survey respondent has all or only part of the meal preparing responsibilities within the household. Respondents self-identifying as meal preparers are asked if, in the previous seven days, they had prepared any meal with meat, poultry, or seafood. Those that did are asked if they used a food thermometer. Hence, the ATUS-EHM is uniquely suited to examine food thermometer use by at-home meal preparers who, during a typical week, are preparing meals that require temperature verification.

Additionally, the ATUS-EHM is well-suited to the task of differentiating thermometer use by occupation, since respondents are sampled from the panel of households that have completed their eighth (final) month of interviews for the Current Population Survey (CPS). The CPS, a monthly survey of households conducted by the Bureau of Census for the Bureau of Labor Statistics, provides a comprehensive body of data on the labor force, employment, unemployment, persons not in the labor force, hours of work, earnings, and other demographic and labor force characteristics.

This study estimates multivariate logit regressions and corresponding average marginal effects to identify specific observable characteristics of at-home meal preparers and their households that may affect the probability that an at-home meal preparer used a thermometer during a typical week when preparing any meal with meat, poultry, or seafood. Our baseline model examines how meal planners' demographic, economic, and household characteristics combine to determine food thermometer use when preparing meals that require temperature verification during a typical week. It includes variables that match and logically extend previous research *(1, 6, 14, 16, 17)*.

The rich set of nationally-representative variables in the ATUS-EHM permit us to extend the baseline estimates relating the probability of at-home thermometer use to standard demographics. The baseline model is augmented in three ways: by variables describing at-home meal preparers' time use and shopping patterns, by health and foodborne illness risk factors, and by industry or occupation of employment.

First, this study hypothesizes that time spent in meal preparation likely influences thermometer use. For example, an at-home meal preparer who spends hours preparing meals may be more likely to use a food thermometer, because of either the amount of food being prepared or the complexity of the preparation. Thus, this study adds to the baseline explanatory variables reflecting meal preparer's time use—shopping venue choice, time spent shopping, and time spent preparing meals—and tests whether food-related time use affects thermometer use.

Next, thermometer use is examined from a health-risk perspective. Advice for consumers from federal health and safety agencies points out that some sub-populations (people with chronic illnesses, children, pregnant women, and older adults) are more susceptible to foodborne illness than others and that such illnesses may have more serious consequences *(8)*. This study hypothesizes that if the relative risk information were better understood by at-home meal preparers, it would create differential incentives to verify temperature and thus lead to different utilization rates of thermometers. Consequently, this study adds to the baseline explanatory variables reflecting at-risk populations—health of the at-home meal preparer, presence of children, and presence of elderly people—and tests whether the presence of at-risk populations affects thermometer use.

Finally, this study examines the influence of occupation on food thermometer use. Given the specific temperature and monitoring requirements faced by restaurants for most of the activities associated with preparing and serving food, this study expects that thermometer use at home is higher

for those employed in food preparation jobs than for those employed elsewhere. This hypothesis follows from public sector requirements of the Food Code—FDA's advice for reducing risk factors for foodborne illnesses and outbreaks for restaurants, retail food stores, and other food-serving operations *(26)*. Nearly all state and local health departments have adopted FDA's Food Code as their system of regulation to ensure that food at retail is safe and properly protected and presented *(27)*.

The Food Code specifies that any food establishment's owner or owner's agent will have a person in charge who can demonstrate knowledge of food safety principles to regulatory authorities by either complying with the Food Code during inspections, passing an accredited training program in food protection, or responding to the inspector's questions about the food operation. At least one employee is required to be a certified food protection manager, who has passed a test as part of a certified program. The Food Code also specifies temperatures for foods received and provides detailed temperature requirements for storing, cooking, reheating, holding, thawing, and cooling foods. Any training that would familiarize a person with the demands of the Food Code would repeatedly emphasize the importance of temperature and of verifying temperature with a thermometer. Even for food service workers who are not directly involved in monitoring temperatures, the ongoing monitoring activity in a food service venue would be hard for other employees to miss. Thus, our hypothesis is that awareness of the importance of temperature monitoring is higher in this sub-population than elsewhere.

Using the employment information from the link with the CPS, this study categorizes employed at-home meal preparers according to the most food-relevant industries and occupations available: leisure and hospitality, accommodation and food service, and food preparation and serving. These variables are added to the baseline model to test whether working in a food service job affects thermometer use at home.

MATERIALS AND METHODS

Data

The American Time Use Survey (ATUS) is a Bureau of Labor Statistics (BLS) survey conducted by the U.S. Census Bureau, with the stated purpose of developing nationally representative estimates of how people age 15 years or older spend their time *(4)*. The objective of the Eating and Health Module (EHM), a component of the ATUS, was to collect data to analyze the relationships among time-use patterns and eating patterns, nutrition, and obesity; food and nutrition assistance programs; food-safety practices and meal preparation; and grocery shopping and food adequacy *(10)*. In the ATUS, individuals are sampled from the panel of households that have completed their eighth (final) month of interviews for the CPS. Those willing to participate are interviewed one time about how they spent their time from 4:00 a.m. the previous day to 4:00 a.m. of the interview day, as well as answering other questions about events within the past seven or 30 days. Since these respondents have already participated in the CPS, demographic information, labor force participation information, and some geographic information is also available.

The ATUS-EHM can be used to focus on the behavior of individuals who make thermometer use decisions. From 2014 to 2016, the ATUS-EHM asked, "Are you the person who usually prepares the meals in your household?" Respondents who answered "yes" or "split it equally with other household member(s)" were asked whether they had prepared any meals with meat, poultry, or seafood in the previous seven days and then asked if they had used a food or meat thermometer when preparing any of these meals. This is the sub-sample of interest. For simplicity, this study refers to usual meal preparers or those who split the task as at-home *meal preparers* and refers to the use of a food or meat thermometer as *food thermometer use*. Given that the time frame of food thermometer use is the previous seven days, the responses allow us to estimate and examine food thermometer use by U.S. at-home meal preparers during an average week. This follows convention, see *(9)*, *(11)*, and *(12)*.

This study pooled the 2014–2016 ATUS-EHM data by combining all three years, resulting in 32,048 completed interviews by respondents age 15 and over. Of the 32,048 interviews, 23,077 respondents were at-home meal preparers age 18 and over. Thus, 23,077 unweighted observations are available for examining at-home meal preparers aged 18 and over. Of these 23,077 at-home meal preparers, 20,300 had prepared at least one meal with meat, poultry, or seafood in the previous seven days. Of these 20,300 meal preparers, 2,499 had used a food thermometer and 17,781 did not; 15 could not recall, and 5 refused to answer. Thus, 20,280 unweighted observations are available for examining the determinants of thermometer use by at-home meal preparers who prepared any meal with meat, poultry, or seafood in the previous seven days.

The CPS uses both a stratified and clustered sampling procedure; the ATUS follows a similar sampling procedure. Because of the survey design, variance estimates must be calculated using replicate weights (WGT1-WGT160). Additionally, a Fay coefficient set equal to .5 and balanced repeated replication (BRR) must be used to correctly estimate standard errors *(3, 20)*. Last, for a pooled sample by year, a final weight (EUFINLWGT) must be divided by the total number of days across all years in the pooled sample *(2, 3)*.

Descriptive variables

The ATUS-EHM contains responses that can be used to examine descriptive characteristics of at-home meal preparers, including their households, time use and shopping behaviors, and presence of populations at-risk of foodborne illness. Available categories to describe at-home meal

preparers include gender, relationship status, age, ethnicity, formal education, and employment status. For gender, this paper defined an indicator for male at-home meal preparers. For relationship status, this paper defined an indicator for married at-home meal preparers. For age, this paper defined an indicator for those age 18 to 34; an indicator for those age 35 to 59; and, an indicator for those age 60 and over. For ethnicity, this paper defined an indicator for Hispanic at-home meal preparers, defined as a respondent who is either Spanish, Hispanic, or Latino *(2)*. For formal education, this paper defined an indicator 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. For employment status, this paper defined an indicator for employed and an indicator for unemployed, and an indicator for not in the labor force.

Available categories to describe the households of at-home meal preparers consisted of household size, geographic location and poverty status. For household size, this paper defined the total number of people in the home. For geographic location, this paper defined an indicator for at-home meal preparers living in the Midwest—defined as living in Iowa, Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, North Dakota, Nebraska, Ohio, South Dakota, or Wisconsin *(2)*. For poverty status, this paper defined an indicator for household incomes exceeding 185% of the federal poverty line, adjusted for household size.

Time use data are available on time spent food shopping, preparing meals, and eating. The ATUS-EHM asks about how many minutes in the last 24 hours you spent grocery shopping; how many minutes in the last 24 hours you spent preparing food, including cleanup; and, how many minutes in the last 24 hours you spent eating as a primary activity, which includes eating and drinking, eating and drinking not elsewhere classified, and eating and drinking as part of a job *(12)*.

The ATUS-EHM asked respondents what type of store they used for the majority of their groceries. Answer choices were grocery store, supercenter, warehouse club, drugstore or convenience store, or some other place. To describe food store preferences, this study defined an indicator for grocery store; an indicator for supercenter or warehouse club; and an indicator for drugstore, convenience store or some other place. The ATUS-EHM also asked respondents to characterize their household's food sufficiency in the past 30 days as enough food to eat, sometimes not enough to eat, or often not enough to eat. To describe food insufficiency, this study defined households as food insufficient if respondents answered either sometimes not having enough to eat or often not having enough to eat.

Populations at risk of foodborne illness include those who are immunocompromised, children, and the elderly. While data on the extent to which at-home meal preparers were immunocompromised is not available in the ATUS-EHM, respondents were asked to rank their physical health on a scale of poor, fair, good, very good, or excellent. This paper defined an indicator for the situation in which an at-home meal preparer was in poor physical health. For the presence of children, the ATUS-EHM asks about the presence of children in the household, either children under the age of 18 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. This paper defined an indicator for the presence of least one child in the household. For the presence of elderly, the CPS recorded the age of each person in the household. This paper defined an indicator for at least one person who was not the at-home meal preparer being age 62 or over.

Regression framework

To explain food thermometer use by at-home meal preparers, this study needs to address the confounding influence that multiple variables, such as demographics, time use, and employment, may have on the decision to whether or not to use a food thermometer. To model this decision-making process, this study assumes that an at-home meal preparer will use a food thermometer if the utility from use, $v_1+\varepsilon_1$, exceeds the utility from nonuse, $v_0+\varepsilon_0$, where v_j is the deterministic component of utility and ε_j is the random component of utility and j indicates an at-home meal preparer's binary choice. The probability of observing an at-home meal preparer choosing to use a food thermometer is equal to the probability that the utility from use exceeds the utility from nonuse:

$$(1)\ \mathbf{Pr}(j = 1) = \mathbf{Pr}(v_1 + \varepsilon_1 > v_0 + \varepsilon_0).$$

This probability simplifies to:

$$(2)\ \mathbf{Pr}(j = 1) = \mathbf{F}(v_1 - v_0),$$

where F is the cumulative density function of $\varepsilon_0 - \varepsilon_1$. Assuming ε_0 and ε_1 are independent and type 1 extreme value distributed, and setting $v_1 - v_0$ equal to $x^T\beta$ where x is a column vector of observable characteristics and β is a column vector of parameters, then the probability that an at-home meal preparer uses a food thermometer reduces to the logit model:

$$(3)\ \mathbf{Pr}(j = 1) = \frac{\exp(x^T\beta)}{1+\exp(x^T\beta)}.$$

Parameters were estimated in Stata® 14 *(19)* for the subsample of at-home meal preparers who reported preparing any meals with meat, poultry, or seafood in the previous week. For clarity, this study refers to this group as "at-home meal preparers" throughout the following discussion of regression results. The resulting logit regression estimates and standard errors were then used to estimate average marginal

effects. For discrete characteristics, the estimated average marginal effect is the average of 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. These average marginal effects were estimated using factor variables in Stata® as recommended by Williams *(28)*.

To understand the determinants of food thermometer use, this study initially examined the impacts of various socio-demographic variables for at-home meal preparers and characteristics describing their household. Specifically, the set of at-home meal preparer characteristics includes an indicator for male or female; an indicator for married or not married; an indicator for age under 35 or 35 and older; an indicator for Hispanic or non-Hispanic; an education indicator for at least a bachelor's degree versus at most some college; and an indicator for being employed or not working, meaning unemployed or not in the labor force. The household characteristics consisted of household size, household location, and household income. Specifically, the total number of people in the household; an indicator for a household located in the Midwest, since Lando and Chen *(14)* found that food thermometer ownership was highest in the Midwest, and an indicator for a household with a total income above 185% of the federal poverty line, adjusted for household size. Year indicators are included to control for possible trends in thermometer use: an indicator for 2015 versus 2014 and an indicator for 2016 versus 2014.

Next, this study examined whether an at-home meal preparer's time use for primary eating, shopping, or meal preparation during an average day affected food thermometer use. Specifically, time-use variables were added to the regressions that controlled for the demographic variables. The variables added included an indicator if an at-home meal preparer used a grocery store for the majority of food shopping needs. This study also included indicators for an at-home meal preparer who spends over 30 minutes on food shopping during an average day, an indicator for spending over 90 minutes on eating during an average day, and an indicator for spending over 120 minutes on food preparation and cleaning during an average day.

This study also examined whether health characteristics of at-home meal preparers, the number of at-risk household members, and food insufficiency affected food thermometer use. Specifically, this study added health-status, at-risk, and food-insufficiency variables to the regression that already controlled for at-home meal preparer demographics and household characteristics. For health status, this study included an indicator for at-home meal preparers who rank their physical health as poor. To examine at-risk populations, this study tested whether the presence of children in the household affected food thermometer use by including an indicator for the presence of at least one child, as well as whether the presence of a household member (other than the at-home meal preparer), over the age of 62 affected food thermometer use. To examine the food environment, this study tested whether a lack of food in the household in the past 30 days affected food thermometer use.

Last, since some workers in the food industry have received formal food safety training or work with someone who has received it, this study examined whether working in a food-service related job influenced food safety practices at home. Specifically, this study categorized at-home meal preparers according to the industries and occupations most relevant to food preparation that are available in the ATUS-EHM: leisure and hospitality, accommodation and food service, and food preparation and serving.

RESULTS

Population-weighted statistics

Descriptive statistics calculated from ATUS for at-home meal preparers are shown in *Table 1*. From 2014 to 2016, 14% of at-home meal preparers were Hispanic, 35% were male, 52% were married, and 45% were between the ages of 35 and 59. For formal education attainment, 39% of at-home meal preparers had at most a high school diploma, 27% had at most an associate's degree, and 34% had at least a bachelor's degree. For general employment status, 3% were unemployed, 37% were not in the labor force, and 60% were employed. The average household size was 2.6 people. For household geographic location, 24% of at-home meal preparers were located in the Midwest. Based on pre-tax income, 63% of surveyed at-home meal preparers had a household income level that exceeded 185% of the federal poverty level, corrected for household size.

When food shopping, 69% of at-home meal preparers primarily used grocery stores, 28% mainly used super centers or warehouse clubs and 3% primarily used drug, convenience or other stores. For physical health, 4% of at-home meal preparers self-rated their physical health as poor. For other household members, 33% of at-home meal preparers lived with at least one child, and 19% lived with a person age 62 or older. For the food environment, 94% of at-home meal preparers had enough to eat while 6% sometimes or often did not have enough to eat.

During an average week, 14% of at-home meal preparers used food thermometers. Descriptively analyzing the same data, Rhodes et al. *(18)* found that at-home meal preparers who used food thermometers earn more than non-users, report better physical health, are more likely married, and have larger households compared with those who did not use food thermometers. They also found that at-home thermometer use was statistically higher for at-home meal preparers working in food service industries or occupations. Specifically, thermometer use at home was 18%, 20%, and 24% for meal preparers who worked in the leisure and hospitality industry, accommodation and food service industry, or food preparation and serving occupations, respectively *(18)*.

How demographics affect food thermometer use

Table 2 provides logit regression estimates for the subsample of at-home meal preparers who reported preparing any meals with meat, poultry, or seafood in the previous week. The point estimates in column 3 suggest that male at-home meal preparers are more likely than female at-home meal preparers to use a food thermometer in an average week. At-home meal preparers who are married are more likely to use a food thermometer than are non-married at-home meal preparers. At-home meal preparers age 18 to 34 are more likely to use a food thermometer than are their counterparts age 35 or older. Hispanic at-home meal preparers are less likely to use a food thermometer than non-Hispanic at-home meal preparers are. At-home meal preparers in larger households are more likely to use a food thermometer, and meal preparers in the Midwest are marginally more likely to use a food thermometer, relative to meal preparers in the rest of the United States. At-home meal preparer characteristics such as education or employment were not statistically significant determinants of food thermometer use. Household income above 185% of the federal poverty line was not a statistically significant determinant of food thermometer use.

The figures in *Table 2*, column 4, represent the estimated average marginal effects of the regression estimates in column 3. As for statistically significant at-home meal preparer characteristics, males are more likely than females to use a food thermometer in an average week by 4.5 percentage points. Married at-home meal preparers are 5.8 percentage points more likely to use a food thermometer than their non-married counterparts are. At-home meal preparers younger than 35 are 5.2 percentage points more likely than older ones to use a food thermometer. Hispanic meal preparers are 4.5 percentage points less likely than non-Hispanic meal preparers to use a food thermometer. With regard to statistically significant household characteristics, the likelihood that an at-home meal preparer uses a food thermometer increases by 0.8% with an increase in the number of people in the household. Although the difference is only marginally significant, at-home meal preparers living in the Midwest are 1.3 percentage points more likely to use a food thermometer than are those living outside the Midwest.

How shopping and time use affect food thermometer use

How time use for primary eating, food shopping, or meal preparation during an average day affected food thermometer use is shown in *Table 3*.

The point estimates in column 1 indicate that at-home meal preparers who shop at a grocery store rather than at all other food stores are more likely to use a thermometer, but the difference is not statistically significant. The point estimates in column 2 indicate that time spent shopping and eating do not statistically affect an at-home meal preparer's use of a food thermometer during an average week. However, at-home meal preparers who spend over 120 minutes on food preparation in an average day are more likely to use a food thermometer during an average week. Column 3 illustrates that the latter statistically significant finding is not sensitive to the inclusion of our grocery store indicator. Column 4 provides the estimated average marginal effects of the regression estimates in column 3. Notably, they indicate that at-home meal preparers who spend over 120 minutes during an average day on meal preparation are 4.5 percentage points more likely to use a food thermometer than those who spend less time on meal preparations. The estimated average marginal effects on at-home meal preparer and household characteristics remain comparable to our previous marginal effects in *Table 2*.

How at-risk populations affect food thermometer use

The effect of the presence of members of at-risk populations on food thermometer use are shown in *Table 4*. The results in column 1 indicate that an at-home meal preparer in poor physical health is less likely than healthier people to use a food thermometer.

The results in column 2 indicate that the presence of at least one child in the home is positively associated with food thermometer 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 in the home is positively associated with food thermometer use by at-home meal preparers, but this point estimate is not statistically significant. The results in column 4 indicate that food insufficiency is positively associated with food thermometer use by at-home meal preparers, but this point estimate is not statistically significant. After all at-risk regressors in column 5 have been included, at-home meal preparer poor health remains negatively associated with food thermometer use. The figures in column 6 provide the estimated average marginal effects of the regression estimates in column 5 and indicate that an at-home meal preparer in poor physical health is 3.7 percentage points less likely to use a food thermometer than is an at-home meal preparer with at least fair physical health. The estimated average marginal effects on at-home meal preparer and household characteristics remain comparable to our previous marginal effects in *Table 2*.

How occupation affects food thermometer use

The results on how occupation may affect food thermometer use are in *Table 5*. Results in column 1 show that at-home meal preparers working in the leisure and hospitality industry were more likely than all others to use a food thermometer at home. The average marginal effect, shown in column 2, indicates that at-home meal preparers working in the leisure and hospitality industry were 4.7 percentage points more likely to use a food thermometer at home. Results in column 3 show that at-home meal preparers working in the accommodation

TABLE 1. Descriptive statistics of U.S. at-home meal preparers and food thermometer use

	Category	Variable	Avg.	Std. Err.
Meal Preparer Characteristics:				
	Gender:	Male	0.35	0.003
	Relationship Status:	Married	0.52	0.004
	Age:	18 to 34	0.26	0.003
		35 to 59	0.45	0.002
		60 and over	0.29	0.002
	Ethnicity:	Hispanic	0.14	0.002
	Formal Education:	H.S. Graduate	0.39	0.003
		Assoc. Degree	0.27	0.004
		B.A. or Better	0.34	0.004
	Employment Status:	Employed (Anywhere)	0.60	0.004
		Unemployed	0.03	0.002
		Not in Labor Force	0.37	0.004
Household Characteristics:				
	Household Size:	Total People in Home	2.62	0.012
	Geographic Location:	Midwest	0.24	0.004
	Poverty Status:	Above 185% of Federal Poverty Line	0.63	0.004
Time Use and Shopping:				
	Time Use (min/day):	Food Shopping	8	0.183
		Food Preparation	48	0.474
		Eating	64	0.400
	Preferred Food Store:	Grocery Store	0.69	0.004
		Super Center or Club	0.28	0.004
		Drug, Convenience, or Other	0.03	0.002
At-Risk Populations:				
	Immunocompromised:	Meal Preparers in Poor Physical Health	0.04	0.002
	Children Present:	At least One Child Present	0.33	0.003
	Elderly Present:	Any Non-meal Preparer Age 62 or over Present	0.19	0.003
	Food Insufficiency:	Sometimes or Often Lack Food	0.06	0.002
Food Thermometer Use:				
	Weekly Use:	Used Food Thermometer	0.14	0.003

Notes: Population weighted proportions and standard errors (averages and standard errors reported for time use in minutes per day) using the ATUS-EHM 2014–2016

and food service industry were more likely than others to use a food thermometer at home. The average marginal effect, shown in column 4, indicates that at-home meal preparers working in the accommodation and food service industry were 7.9 percentage points more likely to use a food thermometer at home. In column 5, at-home meal preparers working in food preparation and serving occupations are seen to be more likely to use a food thermometer at home. The average marginal effect, shown in column 6, indicates that at-home meal preparers working in food preparation and serving occupations were 12.0 percentage points more likely to use a food thermometer at home. The estimated average marginal effects on at-home meal

TABLE 2. Logit estimates for the determinants of food thermometer use by U.S. at-home meal preparers

	(1)	(2)	(3)	(4)
	Meal Preparer Characteristics	**Including Household Characteristics**	**Including Year Indicators**	**Marginal Effects**
At-home Meal Preparer:				
Male	0.359***	0.373***	0.372***	4.49***
	(0.062)	(0.062)	(0.062)	(0.77)
Married	0.597***	0.513***	0.514***	5.83***
	(0.059)	(0.076)	(0.077)	(0.83)
Age 34 or Less	0.460***	0.420***	0.419***	5.24***
	(0.066)	(0.066)	(0.066)	(0.91)
Hispanic	-0.418***	-0.432***	-0.433***	-4.48***
	(0.09)	(0.092)	(0.092)	(0.86)
B.A. or Higher	-0.006	-0.002	-0.003	-0.03
	(0.064)	(0.066)	(0.065)	(0.76)
Employed Anywhere	-0.030	-0.056	-0.056	-0.66
	(0.053)	(0.056)	(0.056)	(0.65)
Household:				
Total People in Home		0.070**	0.069**	0.80**
		(0.028)	(0.028)	(0.33)
Midwest Location		0.107	0.107	1.26
		(0.066)	(0.066)	(0.79)
Income Above 185% of Poverty Line		0.052	0.051	0.59
		(0.068)	(0.068)	(0.78)
Year Indicators:				
Year 2015			0.135**	1.59*
			(0.07)	(0.83)
Year 2016			0.077	0.91
			(0.069)	(0.82)
n	20,280	20,280	20,280	20,280

Notes: Logit regression estimates are provided in columns 1–3. Average marginal effects are provided in column 4 and are based on the logit regression estimates in column 3. Standard errors are in parentheses. *$P < .10$; **$P < .05$; ***$P < .01$

preparer and household characteristics remain comparable to our previous marginal effects in *Table 2*.

DISCUSSION AND CONCLUSIONS

Federal health and safety officials offer advice to meal preparers on ways they can reduce the likelihood of food-borne illness for themselves and their families. For example, foodsafety.gov, a website managed by the U.S. Department of Health and Human Services (HHS) as a collaborative effort of the White House, HHS, the U.S. Department of Agriculture (USDA), the FDA, the Centers for Disease Control and Prevention (CDC), and the National Institutes of Health, has as its stated purpose the consolidation of food safety information produced by federal regulatory agencies and the provision of current information about food safety to the public *(13)*. There, consumers are advised about the

TABLE 3. Logit estimates examining if time use and shopping choices affect food thermometer use

	(1)	(2)	(3)	(4)
	Added Shopping Choice	**Added Time Use**	**Added Both**	**Marginal Effects**
Baseline Controls:				
Male	0.33***	0.39***	0.35***	4.15***
	(0.06)	(0.06)	(0.06)	(0.79)
Married	0.54***	0.50***	0.53***	5.91***
	(0.08)	(0.08)	(0.08)	(0.9)
Age 34 or Less	0.38***	0.43***	0.39***	4.77***
	(0.07)	(0.07)	(0.07)	(0.99)
Hispanic	-0.44***	-0.46***	-0.46***	-4.63***
	(0.1)	(0.09)	(0.1)	(0.89)
B.A. or Higher	0.02	-0.004	0.02	0.23
	(0.07)	(0.07)	(0.07)	(0.78)
Employed Anywhere	-0.03	-0.02	0.01	0.13
	(0.06)	(0.06)	(0.06)	(0.66)
Total People in Home	0.06**	0.06**	0.05*	0.61*
	(0.03)	(0.03)	(0.03)	(0.34)
Midwest Location	0.07	0.11*	0.07	0.80
	(0.07)	(0.07)	(0.07)	(0.78)
Income Above 185% of Poverty Line	-0.002	0.06	0.01	0.09
	(0.07)	(0.07)	(0.07)	(0.78)
Year 2015	0.10	0.13*	0.10	1.11
	(0.07)	(0.07)	(0.07)	(0.84)
Year 2016	0.02	0.08	0.03	0.29
	(0.07)	(0.07)	(0.07)	(0.8)
Shopping Choice:				
Grocery Store	0.09		0.09	1.03
	(0.06)		(0.06)	(0.68)
Time Use (avg. day):				
Over 30 min. Food Shopping		-0.07	-0.06	-0.62
		(0.09)	(0.1)	(1.06)
Over 90 min. Eating		0.06	0.03	0.34
		(0.07)	(0.07)	(0.85)
Over 120 min. Preparing Meals		0.36***	0.36***	4.45***
		(0.08)	(0.08)	(1.13)
n	18,556	20,280	18,556	18,556

Notes: Logit regression estimates are provided in columns 1–3. Average marginal effects are provided in column 4 and are based on the logit regression estimates in column 3. Standard errors in parentheses. *$P < .10$; **$P < .05$; ***$P < .01$

TABLE 4. Logit estimate examining if health measures and at-risk populations affect food thermometer use

	(1)	(2)	(3)	(4)	(5)	(6)
	Meal Preparer Health	**Children Present**	**Elderly Present**	**Lack Food**	**Added All**	**Marginal Effects**
Baseline Controls:						
Male	0.37***	0.37***	0.38***	0.37***	0.38***	4.62***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.77)
Married	0.51***	0.51***	0.50***	0.52***	0.49***	5.61***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.86)
Age 34 or Less	0.42***	0.42***	0.43***	0.42***	0.43***	5.34***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.93)
Hispanic	-0.43***	-0.43***	-0.43***	-0.44***	-0.43***	-4.48***
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.86)
B.A. or Higher	-0.02	-0.004	0.002	-0.003	-0.01	-0.14
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.75)
Employed Anywhere	-0.06	-0.06	-0.04	-0.06	-0.05	-0.60
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.69)
Total People in Home	0.07**	0.06*	0.07**	0.07**	0.06	0.64
	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)	(0.43)
Midwest Location	0.10	0.11	0.11	0.10	0.11	1.25
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.81)
Income Above 185% of Poverty Line	0.05	0.05	0.05	0.05	0.06	0.69
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.78)
Year 2015	0.14**	0.14*	0.13*	0.14**	0.14*	1.64*
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.84)
Year 2016	0.08	0.08	0.08	0.08	0.08	0.93
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.82)
Health Controls:						
Poor Physical Health	-0.36**				-0.36**	-3.72**
	(0.18)				(0.18)	(1.62)
At-risk Populations:						
Children Present		0.04			0.07	0.84
		(0.08)			(0.08)	(0.98)
Elderly Present			0.10		0.11	1.32
			(0.08)		(0.08)	(1.00)
Food Environment:						
Lack Enough Food				0.04	0.09	1.08
				(0.14)	(0.14)	(1.77)
n	20,160	20,280	20,280	20,236	20,141	20,141

Notes: Logit regression estimates are provided in columns 1–5. Average marginal effects are provided in column 6 and are based on the logit regression estimates in column 5. Standard errors in parentheses. *$P < .10$; **$P < .05$; ***$P < .01$

TABLE 5. Logit estimate examining if food-service employment affects food thermometer use

	A. Leisure		B. Accommodations		C. Food Service	
	(1)	(2)	(3)	(4)	(5)	(6)
	Logit Estimates	Marginal Effects	Logit Estimates	Marginal Effects	Logit Estimates	Marginal Effects
Baseline Controls:						
Male	0.37***	4.51***	0.38***	4.56***	0.38***	4.59***
	(0.06)	(0.77)	(0.06)	(0.77)	(0.06)	(0.77)
Married	0.53***	5.99***	0.54***	6.05***	0.53***	6.01***
	(0.08)	(0.82)	(0.08)	(0.81)	(0.08)	(0.83)
Age 34 or Less	0.41***	5.09***	0.40***	5.00***	0.40***	4.96***
	(0.07)	(0.91)	(0.07)	(0.91)	(0.07)	(0.92)
Hispanic	-0.44***	-4.53***	-0.44***	-4.57***	-0.44***	-4.55***
	(0.09)	(0.86)	(0.09)	(0.86)	(0.09)	(0.86)
B.A. or Higher	0.005	0.06	0.01	0.16	0.02	0.28
	(0.06)	(0.75)	(0.07)	(0.75)	(0.07)	(0.76)
Employed Anywhere	-0.08	-0.93	-0.09	-1.01	-0.10*	-1.16*
	(0.06)	(0.66)	(0.06)	(0.65)	(0.06)	(0.65)
Total People in Home	0.07**	0.78**	0.07**	0.76**	0.07**	0.79**
	(0.03)	(0.32)	(0.03)	(0.32)	(0.03)	(0.33)
Midwest Location	0.11	1.28	0.11	1.27	0.11	1.25
	(0.07)	(0.79)	(0.07)	(0.79)	(0.07)	(0.79)
Income Above 185% of Poverty Line	0.06	0.69	0.07	0.75	0.07	0.81
	(0.07)	(0.78)	(0.07)	(0.79)	(0.07)	(0.79)
Year 2015	0.13*	1.56*	0.13*	1.57*	0.13*	1.57*
	(0.07)	(0.83)	(0.07)	(0.83)	(0.07)	(0.84)
Year 2016	0.08	0.90	0.07	0.87	0.07	0.87
	(0.07)	(0.81)	(0.07)	(0.81)	(0.07)	(0.81)
Industry or Occupation:						
Leisure, Hospitality	0.37***	4.74**				
	(0.13)	(1.92)				
Accommodation			0.57***	7.86***		
			(0.16)	(2.51)		
Food Preparation					0.81***	12.01***
					(0.14)	(2.60)
n	20,280	20,280	20,280	20,280	20,280	20,280

Notes: Logit regression estimates and corresponding average marginal effects are provided. Standard errors in parentheses.
*$P < .10$; **$P < .05$; ***$P < .01$

importance of cleaning (washing hands and food preparation surfaces often; minimizing cross-contamination); maintaining separate cutting boards and plates for produce and for meat, poultry, seafood, and egg dishes, as well as storing the two groups of foods separately; refrigerating perishable foods promptly, and cooking foods to safe temperatures *(7)*. Fed-

eral agencies' advice about safe temperatures is unequivocal: food that is cooked until it reaches the thermometer-verified temperature officials recommend is considered safe, and food that is cooked without use of a thermometer to verify internal temperature is not safe *(7)*.

USDA's Food Safety and Inspection Service (FSIS) offers more detailed guidance about achieving and verifying that a food has reached the recommended temperature. The agency offers guidance on how to select a thermometer *(24)*. It explains when to use a thermometer during the cooking cycle and how to clean a thermometer *(23)*. Directions for placing a thermometer in a wide array of meats, casseroles, and egg dishes are provided *(22)*.

FSIS also explains the research that guided its recommendations, showing that color and texture of cooked ground beef is not a good guide to safety: sometimes ground beef will turn brown before reaching the safe temperature of 160°F. Further, the agency advises consumers that its pre-1997 advice to cook ground beef patties until the center and the cooked-out juices are no longer pink and to look for a firm "cooked" texture were insufficient to make meat safe *(21)*. In 1997, FSIS began recommending that consumers cook hamburgers to 160°F and verify this temperature with a thermometer. Both CDC and FDA followed in 1998 *(17)*. To make sure that consumers are aware of its advice, the agency has an outreach program and monitors consumer food-safety behavior so as to modify its efforts to promote food safety *(25)*.

Clearly, the federal government provides food safety information along with easy-to-follow instructions for thermometer use. Undoubtedly, following the instructions would prevent many foodborne illnesses. Since the costs of thermometer use seem low and the benefits appear to be high, cost-benefit decision making on the part of at-home meal preparers should make thermometer use nearly universal. However, using the 2014–2016 Eating and Health Module from the American Time Use Survey, this study found that only 14% of meal preparers use food thermometers during a typical week when preparing meals that require verification to ensure safety.

The federal government provides detailed warnings regarding the food safety risks to children, pregnant women, the elderly, and the immunocompromised. Therefore, households that include members of any of these at-risk groups would have a strong incentive to take action to avoid foodborne illness. However, our regression results found evidence that the presence of children, the elderly, or food insufficiency had no influence on food thermometer use. Further, this study found, counterintuitively, that at-home meal preparers who judged themselves to be in poor physical health were less likely than those in better physical health to use a food thermometer.

Local, state and federal governments provide guidance and oversight of food safety in food-service industries. The FDA Food Code requires at least one employee at all hours of operation to be a certified food protection manager who has passed a test as part of a certified program. Such training would familiarize a person with the demands of the Food Code that repeatedly emphasize the importance of temperature and verifying temperature with a thermometer. Further, health code violations accrue for not following proper food safety temperature, sanitation, and hygiene guidelines. Given this oversight and regulatory environment, an expectation is that those working in food-service jobs likely better understand food safety than others and thus have a higher propensity to utilize food safety practices at home.

This study did find that food service employment is related to at-home food thermometer use. Workers in leisure and hospitality, accommodation and food service, and food preparation and serving are each more likely than others to use a food thermometer at home. The largest difference was for the group employed in food preparation and serving, a job category that most likely includes workers who have had food safety training and that showed almost twice the use of thermometers at home as seen for other workers.

The training food service workers receive appears to go beyond work in commercial kitchens and carries over to behavior in the home. Had there been no detectable difference based on food service employment, it would be reasonable to infer that mandatory training did not influence home behavior. It would then be unreasonable to expect greater impacts from voluntary programs. That is, it would be unreasonable to expect outreach programs, which are inherently voluntary, to do what mandatory training cannot. There would therefore be little economic argument for maintaining government-financed outreach and voluntary education programs.

While this study found that food preparation and serving workers, compared with all other survey respondents, were 12 percentage points more likely to use food thermometers at home when preparing meals that require temperature verification, the average rate of use was still only 24% for those working in food preparation and serving *(18)*. That still leaves more than three quarters of food service workers who fail to use a thermometer when they prepare at-home meals that require temperature verification.

For future policy consideration, low thermometer use rates may indicate that the public health community has not done enough to convince meal preparers that temperature verification is worthwhile. This admits at least three possibilities that might be resolved through further studies of factors that influence food safety behavior. Meal preparers may not be convinced that temperature verification would help them avoid foodborne illness; they may not be aware of the adverse consequences of foodborne illness, or the ease of avoiding some foodborne illnesses may not be understood. The findings of this study, that differences in thermometer usage were related to gender, marital status, age, and ethnicity, may assist in future outreach efforts.

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