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Temporal dietary patterns derived among the adult participants of NHANES 1999-2004 are associated with diet quality

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Abstract

Background—Temporal dietary patterns, the distribution of energy or nutrient intakes observed over a period of time, is an emerging area of dietary patterns research that incorporates time of dietary intake with frequency and amount of intake to determine population clusters that may have similar characteristics or outcomes related to diet quality.

Objective—This study examined whether differences in diet quality were present between clusters of individuals with similar daily temporal dietary patterns.

Design—The first day 24-hour dietary recall data from the cross-sectional 1999-2004 National Health and Nutrition Examination Survey (NHANES) were used to determine proportional energy intake, time of intake, frequency of intake occasions, and mean diet quality.

Participants/setting—Data from 9,326 US adults 20-65 years were included.

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Statistical analyses performed—The mean diet quality, classified by the Healthy Eating Index-2005, of participant clusters with similar temporal dietary patterns derived on the basis of individual proportional energy intake, time of intake, and frequency of intake, were inferentially compared using multiple linear regression that controlled for potential confounders and other covariates ($P<0.05/6$).

Results—Diet quality differences were present between US population clusters exhibiting similar daily temporal dietary patterns ($P<0.001$ with one exception, $P=0.08$). Participant characteristics of race/ethnicity, age, household poverty-income ratio, and body mass index were associated with the temporal dietary patterns. The cluster representing the temporal dietary pattern with proportionally equivalent energy consumed during three evenly spaced eating occasions had a significantly greater mean total Healthy Eating Index-2005 score compared with the other temporal dietary pattern clusters.

Conclusions—Temporal dietary patterns are associated with differences in US adult daily diet quality, demonstrating that elements beyond food and nutrient intake, such as time, can be incorporated with dietary patterns to determine links to diet quality that enhance knowledge of the complicated interplay of time and daily patterns.

Keywords

temporal dietary patterns; Healthy Eating Index; dietary intake; diet quality; dietary patterns

Introduction

The topic of dietary patterns is an emerging research area that incorporates multiple dietary characteristics, such as foods or nutrients, in analysis, and is often explored in relation to a particular health or dietary outcome.¹⁻⁵ This multi-faceted approach represents an inclusive investigation of the diet-health relationship that may reveal stronger associations between indicators of health and the role of diet compared with singular nutrient or dietary component approaches.⁵ However, the incorporation of *time* of day to dietary patterns has not been previously considered despite observations suggesting that temporal patterns may exist. Temporal dietary patterns is a novel foray incorporating the distribution of time as a primary component of dietary patterns.⁶ For example, the amount of energy or nutrient consumed at a certain time may influence the amount of energy or nutrient consumed at the next eating occasion, or be related to total daily energy intake.^{7,8} Time of energy and nutrient intake can be used to describe the temporal distribution of dietary intake during a 24-hour period. Examining food or energy intakes temporally provides a relatively objective descriptor of when a food was consumed in comparison to the examination of food or energy intake based on a subjectively labeled intake occasion such as “breakfast” or “dinner”.^{9,10} Temporal classification avoids the cultural and personal constructs that are associated with the names assigned to various intake occasions throughout the day. For example, dinner for one individual may be understood as a meal eaten at noon, while for another individual, dinner may imply a meal eaten in the evening.

Previous documented attempts to carry out temporal analysis of dietary intake in relation to food based dietary guidance encountered “many methodological issues”¹¹ and “one of the

major methodological issues was statistical analysis".¹¹ The research described herein addresses these previously identified challenges by applying a novel distance metric based on the dynamic time warping technique used in speech processing^{12,13} to identify similarities in the time of intake, frequency of intake and magnitude of proportional energy intake over a 24-hour period and reduce the data using cluster analysis.⁶ Groups displaying similar energy intake features, or temporal dietary patterns, are expected to exhibit a similar quality of dietary intake that is distinct from other temporally defined groups. Therefore, the hypothesis addressed in this study was that differences in diet quality, classified using the Healthy Eating Index-2005 (HEI-2005),¹⁴ exist between US adult (ages 20 to 65 years) participant clusters exhibiting similar 24-hour temporal dietary patterns as generated from the 24-hour dietary recalls of the 1999-2004 National Health and Nutrition Examination Survey (NHANES).

Methods

Study population

This study was a secondary analysis of dietary data from the nationally representative NHANES 1999-2004 and included all necessary variables for application of the novel data patterning methodology. This cross-sectional survey was conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention.¹⁵ Participants of the survey represent the non-institutionalized, civilian, US population and were selected according to age, sex, and race-ethnicity using complex, multi-stage, probability sampling methods. The questionnaire portion of the survey completed in the participant's home included collection of race/ethnicity, sex, age, income, and other information. The health examination, completed in the NHANES Mobile Examination Center, included the collection of height and weight to determine body mass index (BMI) and a 24-hour dietary recall using the United States Department of Agriculture (USDA) automated multiple-pass method. Consent was required for all participants.¹⁶ NHANES protocols and content were thoroughly reviewed by the National Center for Health Statistics Research Ethics Review Board who also granted approval.¹⁷ Data drawn in this analysis included non-pregnant adults ages 20 to 65 years with a complete, reliable 24-hour dietary recall ($n=9,326$). Children, teens, and adults over retirement age were not included in the analysis as the daily patterns of these age groups may include variation inherent to the life-stages they represent.

Dietary assessment

The USDA automated multiple pass method¹⁸ 24-hour dietary recall was used to assess dietary intake. Participants took approximately 30 to 45 minutes to complete the five passes, or series of probes, to recall as many foods and beverages as possible that were consumed in the past 24 hours and their respective times of consumption. Duration of eating occasions was not reported. The reported dietary information was linked to the USDA Food and Nutrient Database for Dietary Studies for 2001-2004 data and to the USDA 1994-98 Survey Nutrient Database for 1999-2000 data.¹⁹⁻²¹ The food composition databases included information on approximately 7,000 foods. Appropriate energy content was assigned to each reported food or beverage.

The HEI-2005, a numeric score ranging from 0 to 100, was calculated for each participant and was used as an indicator of diet quality for intake over one 24-hour day. HEI-2005 was chosen as an appropriate outcome indicator to maintain consistency with the 24-hour time period that was integral in defining the temporal dietary pattern clusters used as an independent variable in the analysis. Adherence to the 2005 Dietary Guidelines for Americans was estimated using the HEI-2005 with a high score representing a high quality diet and a low score representing a low quality diet. The HEI-2005 is comprised of 12 numerically scored components: total vegetables; dark green and orange vegetables and legumes; total fruit; whole fruit; total grains; whole grains; milk; meat and beans; oils; saturated fat; sodium; and energy from solid fats, alcohol, and added sugars. A sum of the 12 scores determined the total HEI-2005 score for one 24 hour day.¹⁴ Details regarding calculation of the HEI-2005 are provided elsewhere.²² Based on evidence provided by the HEI-2005 sample distribution and further normality tests, the assumption of normality was not rejected.

Temporal dietary patterns

A detailed description of the methodology used to determine the temporal dietary patterns has been previously described by Khanna et al.⁶ A brief narrative is provided here, including exceptions to the published methods applied in this analysis. Twenty-four dimensional feature vectors, equating to the 24 hours in one day, were used to represent the fractional energy consumed during an hourly time interval compared to the energy consumed in the entire 24 hours of the day. Various distance metrics were considered for comparing the feature vectors based on the pattern of non-zero elements. A novel distance metric, or kernel, based on dynamic time warping was selected to map similar intake occasions together based on energy contribution, time of dietary intake, and number of intake occasions, and was optimized for the 24-hour dietary data.^{6,12}

Data analysis

Kernel k-means clustering with custom kernel were performed for $c=2$ to $c=7$ clusters.^{13, 23-27} $C=4$ was selected to divide the population into clusters representing similar temporal dietary patterns as this provided the greatest diversity between the groups regarding the selected characteristics of interest. Differences between the participant clusters were evaluated by selected characteristics including sex by male or female; race/ethnicity by non-Hispanic white, non-Hispanic black, Mexican American, other Hispanic and other race/ethnicity; survey years 1999-2000, 2001-2002, and 2003-2004; age groups 20-34, 35-49, and 50-65 years; BMI categories of underweight, normal weight, overweight, and obese;^{28, 29} and household poverty-income ratio (PIR) by the six category grouping of 0-0.99, 1-1.99, 2-2.99, 3-3.99, 4-4.99, and 5 or more. Household PIR was calculated as reported household income divided by the federal poverty guideline for household income. All household PIRs greater than five were coded as five. The Rao Scott F-adjusted Chi Square statistic was used to determine significant differences between the clusters by characteristics.

Analysis of variance was used to find differences in the mean total HEI-2005 score for the $c=4$ clusters. Adjusted models for sex, race/ethnicity, age group, BMI, survey year, and

household PIR were created to further examine differences in the clusters with regard to mean total HEI-2005 score. A multiple linear regression model accommodated the dependent variable total HEI-2005 score and the four category independent variable represented by the c=4 temporal dietary patterns. Proper survey weights were constructed for the 1999-2004 timeframe as directed by the National Center for Health Statistics.³⁰ Weights were rescaled so that the sum of the weights matched the survey population at the midpoint of the six years covering 1999-2004. Adjustments for the complex survey design, including clustering and stratification, were applied to all analyses allowing inference to the non-institutionalized US population. Analyses were completed in Matlab v 7.10.0 (The Mathworks Inc. 2010. Natick Massachusetts), SAS 9.2 (SAS Institute Inc. 2009. Cary, NC), and SAS Survey procedures. Comparisons between groups were considered statistically significant when $P < 0.05/6$ (Bonferroni type adjustment for multiple comparisons of cluster HEI means). Visualization of the temporal dietary patterns was also explored to enhance understanding of the way the patterns differed. Two figures were created to show the relative frequency of the time of energy intake events by cluster on the 24-hour time scale.

Results

The visual presentation of the time of the largest daily energy intake event by the proportion of individuals in each cluster (Figure 1) over a 24-hour time scale demonstrates the four distinct temporal dietary distributions of energy intake. The relative frequency of the intake events of Cluster 1 were modest with regard to proportional energy consumed compared with the relative frequency of the intake events of the other clusters and included a relatively frequent intake event as a small peak at 9:00 a.m., and two distinct additional relatively frequent intake events at 12:00 p.m. and 6:00 p.m. to 7:00 p.m. Dietary patterns representing the second largest intake event (Figure 2) for Cluster 1 were similar to the largest intake event with respect to the 12:00 p.m. relatively frequent event; however the smaller morning and evening relatively frequent intake events extended over a greater span of time, from 8:00 a.m. to 10:00 a.m. and 6:00 p.m. to 8:00 p.m., respectively. Taken together, the results suggest that Cluster 1 consumes similar proportions of energy at more time periods throughout the day compared with the other clusters. The other three clusters exhibited patterns with dramatic relative frequency for energy intake events, representing high conformity among the cluster for timing of the largest and second largest intake events and a great proportion of energy consumed at those events. Cluster 2 demonstrated the largest intake event as peak from 4:00 p.m. to 10:00 p.m. and the second largest intake event as a dramatic relatively frequent intake event from 7:00 a.m. to 3:00 p.m. while Cluster 3 participants demonstrated a dietary pattern in the reverse order compared with Cluster 2 for the largest and second largest intake events. The majority of participants comprising Cluster 4 reported the intake event of greatest energy value sometime during the time of 11:00 a.m. to 9:00 p.m. The second largest intake event for many Cluster 4 participants was less defined, with relatively frequent intake events identified at 12:00 a.m., from 7:00 a.m. to 10:00 a.m., 11:00 a.m. to 1:00 p.m., 7:00 p.m. to 8:00 p.m., and 9:00 p.m. to 10:00 p.m.

Selected characteristics of the clusters representing the temporal dietary patterns are shown in Table 1. Clusters 2 and 3 included similar numbers of participants while Cluster 4 included the least participants or approximately one quarter the participants of Cluster 1, the

largest cluster. Significant differences were present among clusters by race/ethnicity ($P<0.0001$), household PIR ($P<0.001$), age ($P<0.01$), and BMI ($P<0.0001$), but not by survey year or sex. Further description of these overall differences is offered by observation of the n and % given in Table 1. The non-Hispanic white group may be more heavily represented in Clusters 1 and 2 when contrasted with Clusters 3 and 4. The non-Hispanic black group featured prominently in Cluster 4 (27.2%) as contrasted with the other clusters (19.6%-22.2%). Mexican Americans were proportionally prominent in Cluster 3 (28.6%) compared with the other clusters (21.7%-23.3%), and Clusters 2, 3 and 4 had proportionally high representation of the “other Hispanic and other race/ethnicity” group (9.3%-9.9%) considering the percentage observed for Cluster 1 (7.7%). Cluster 1, Cluster 2, and Cluster 3 had proportionally greater representation in one of the three age groups 50-65 years (33.7%), 35-49 years (36.5%), and 20-34 years (34.5%), respectively, when contrasted with the other clusters. Smaller proportions of individuals at the lowest household PIR of 0 to 0.99 were included in Cluster 1 (17.5%) and Cluster 2 (17.0%) while larger proportions were included in Clusters 3 (20.2%) and 4 (25.1%). The proportional representation of Clusters 1 and 2 in the higher ratios of household PIR (4.00-4.99 and >5.00) compared with Clusters 3 and 4 was also observed. Regarding BMI, normal weight was more highly represented in Cluster 1 (33.0%) compared with the other clusters (25.7%-29.5%) while the obese category were most highly represented in Cluster 2, 3, and 4 (34.4%-35.6%) as contrasted with Cluster 1 (31.2%). Significant differences in mean total HEI-2005 score were present among all clusters in unadjusted models ($P<0.05/6$, simple regression model results not shown) and among all clusters ($P<0.05/6$, Table 2) except for Clusters 2 and 3 in adjusted models. Cluster 1 had the highest mean total HEI-2005 score (51.4(0.3)) compared with the other clusters while Cluster 4 had the lowest mean total HEI-2005 score (45.4(0.6)).

Analysis to determine the dependence of mean total HEI-2005 score on cluster when controlling for the selected characteristics: age, sex, survey year, race/ethnicity, household PIR, and BMI, indicated significant differences at $P<0.001$ (Table 2) for all cluster relationships except for the relationship between Cluster 2 compared with Cluster 3 ($P=0.08$). The significantly different mean total HEI-2005 scores for the clusters were greatest between Clusters 1 and 4 ($\beta=5.9(0.7)$), similar to the results of the unadjusted model ($\beta=5.8(0.7)$, data not shown). Cluster 1 ranked highest in diet quality followed by Clusters 2 and 3 and Cluster 4, ranking the lowest in daily diet quality.

Discussion

Diet quality was associated with temporal dietary patterns generated from 24-hour dietary recalls of a representative sample of US adults in this study. The authors are not aware of any other study that documents the derivation of dietary patterns from the integration of reported *time* of dietary intake, intake frequency, and the daily proportional energy consumed at each intake occasion. Previous studies have shown that food derived dietary patterns are associated with diet quality.^{2,3,31} However, these studies used only food and beverage intakes to define dietary patterns, without the additional contextual information used here. The mean total HEI cluster score differences associated with temporal dietary patterns in this study were relatively small, as such, the large sample size cannot be ruled out as an explanation for these cluster differences. However, even total HEI-2005 score

differences of only two points were associated with clinically meaningful measures of poorer longitudinal glycemic control in a previous study.³² Thus, the total HEI-2005 score differences observed in this study indicate temporal dietary patterns as a meaningful health exposure that merit continued methodological development and refinement for pattern derivation. Further, the temporal dietary patterns associated with the mean total HEI-2005 score in this analysis were also related to certain characteristics (Table 1) that are mediators of diet-related health disparities.^{33,34}

The mean estimates of single-day total HEI-2005 score for all clusters were relatively low compared with the total possible score of 100 on the HEI-2005. The finding of better diet quality associated with Cluster 1 compared with the other clusters, suggests that evenly spaced, energy balanced eating occasions throughout the daytime may provide more opportunities for selecting foods that meet dietary recommendations.³⁵ Individuals comprising Cluster 1 exhibited a temporal dietary pattern associated with the highest diet quality compared with the temporal dietary patterns of other clusters. The individuals in Cluster 1 may be more interested in following dietary recommendations which generally include advice to consume food at regular intervals throughout the day. On the other hand, the daily pattern of energy consumption during evenly spaced occasions throughout the day may provide individuals comprising Cluster 1 a dietary context facilitating higher quality dietary choices compared with the other temporal dietary patterns. Thus, it is difficult to disentangle which is more influential: engaging in healthful dietary behaviors, following specific times for eating, or both. Despite causal ambiguity, the association of energy balanced eating occasions throughout the day characterized by Cluster 1 with higher diet quality compared with other temporal dietary patterns clusters provides unique evidence among studies supporting the current Dietary Guidelines.³⁵

Cluster 4 was associated with the lowest diet quality when compared with all other clusters. Unique aspects of the temporal dietary pattern characterizing the second largest consumption event of Cluster 4 participants included a distinct relatively frequent consumption event at 12:00 a.m. and the presence of five total relatively frequent consumption events throughout the day. The relatively frequent midnight consumption event is suggestive of a daily lifestyle pattern that is not synchronized with normal daylight hours and may include night shift workers. Previous studies have shown an association between night shift work and more frequent energy consumption events, or snacking, during waking hours.^{36,37} Thus, the small, frequently peaked temporal dietary pattern observed among Cluster 4 participants may indicate more frequent snacking or energy consumption events throughout the day compared with participants comprising the other clusters. If, indeed, night shift workers were more highly represented in Cluster 4 compared with the other clusters, the lower diet quality score exhibited is similarly consistent with previous research suggesting lower diet quality among night shift workers compared with day workers.³⁷ Knutson et al³⁸ reported reduced consumption of green vegetables/potatoes and higher intake of soft drinks after individuals started shift work which would be consistent with a lower quality diet. The hypothesized explanation of greater prevalence of shift workers comprising Cluster 4 may also aid an explanation for the finding of higher proportion of overweight and obesity in Cluster 4 compared with other clusters. Night shift workers had a higher prevalence of short sleep duration compared with day shift workers³⁹ and night shift

work was an independent risk factor for obesity.⁴⁰ Short sleep duration is also associated with higher BMI.^{41,42} These links, although hypothesized and based on the temporal aspect of dietary intake, support emerging research examining the relationship of circadian rhythms to dietary intake, body weight, and metabolism.^{36,41}

The higher proportion of non-Hispanic white participants and lower proportion of non-Hispanic black participants in the two clusters with higher mean total HEI-2005 score and the reverse proportional race/ethnic relationships among the clusters with lower mean total HEI-2005 score, support previously documented findings of dietary disparities among non-Hispanic black compared with the non-Hispanic white group.^{33,34} These findings also offer an explanation of the health disparities that exist among these race/ethnic groups.⁴³⁻⁴⁶ Diets of lower diet quality have been linked with negative health outcomes, hence the current recommendations for a healthful overall diet.³⁵ Similarly, the high proportion of participants with a household PIR level of 0-0.99 included in the clusters associated with the lowest mean total HEI-2005 score (Clusters 3 and 4) and a correspondingly low proportion of participants with a household PIR of 0-0.99 in the clusters associated with the highest mean total HEI-2005 score (Clusters 1 and 2) corroborates previous work indicating dietary disparities among low-income groups.³³ A greater disease burden has been documented among the low-income population compared with higher income groups.⁴⁷⁻⁴⁹ Attributes to race/ethnicity and income are difficult to separate as they are closely associated and often represent similar groups. Taken in context with the proportional differences in BMI among the clusters, the temporal dietary pattern associated with the highest diet quality, included a higher proportion of normal weight compared with overweight and obese participants, non-Hispanic white compared with non-Hispanic black and Mexican American participants, and a lower proportion of lower income compared with higher income participants. The dietary pattern associated with the lowest diet quality was more heavily represented by characteristics: overweight and obese, low household PIR, and non-Hispanic black. Prospective studies in the 1946 British birth cohort found that the daily schedule of energy intake has shifted over time with a greater proportion of intake later in the day.¹⁰ These shifts may contribute to health problems, such as metabolic syndrome.⁹ This evidence, combined with the results of our study, suggest that the schedule of regular eating times may be a contributing factor to health disparities as may health disparities contribute to the pattern of dietary intake.

Temporal analysis of food intake may be useful to develop effective time and food-based dietary guidelines.^{11,43,50} Intake at certain times of the day may be associated with foods that are recommended for reduction in the dietary guidelines and diets that are less supportive of overall health. Using dietary data from the 1946 British birth cohort, Burke et al¹¹ found consistent mealtime peaks for morning, afternoon, and early evening for the consumers of white bread, wholemeal bread, total cereals, reduced and full-fat milk and total dairy. A different pattern of intake throughout the day was present for those that consumed cakes.¹¹ The present study contributes evidence for moderate daily noon and evening eating events associated with higher diet quality.

Elements beyond food and nutrient intake such as the *time* of intake can be an important aspect of dietary patterns and may describe diet better within the context of lifestyle. Time

may have other relationships to diet and health that were not included in this research. The possibility exists that daily time patterns within the larger context of weekly or seasonal time patterns may also be associated with health or dietary outcomes. This concept is similar to combining the 24-hour dietary recall and a food frequency questionnaire to better identify the consumption of episodically consumed foods.⁵¹ Daily energy or other nutrient intake patterns may be ‘micro-patterns’ that are part of larger dietary intake patterns associated with other daily patterns such as activity and sleep-wake schedules. Knowledge of these multi-faceted and interacting patterns may illuminate stronger associations to health outcomes when they are considered together, in contrast to when each component is considered separately. Data to conduct such research is increasingly available with technology assisted dietary assessment. Longitudinal datasets derived from technology assisted dietary assessment may include eating, waking and activity time, and other contextual information such as location and duration of the eating occasion. Methods to incorporate these layers of interacting and sometimes non-independent data remain a challenging barrier. The melding of traditional analytical methods used in epidemiology and other areas of nutrition science with techniques used in other disciplines, such as engineering and speech processing, which were used in this study, have the potential to offer novel solutions for temporal dietary patterns. Methods outside of the disciplines incorporated here are a rich resource for further applications.

Strengths of this study are the comprehensive approach to classifying a dietary exposure that accounts for the complexity of intake over a 24-hour day rather than for a single intake occasion or a generalized characterization of intake for the entire day. An extension of the methodology used in this study may be applied in the future to analyze the growing temporal data from personal health monitoring devices. The methodology used here to create temporal dietary patterns to compare clusters by mean total HEI-2005 score performed similarly, regarding signal to noise characteristics, when compared to the use of traditional clustering methods based on the reported eating occasion (such as by consuming breakfast or snacking frequency)^{52,53} but the results demonstrate efficacy that can be improved by methodological refinement in future studies. In addition, the methods used to create the temporal dietary patterns described in this paper have addressed some of the obstacles noted in previous studies.¹¹ The use of time of day, frequency, and proportional energy intake for clustering rather than reported eating occasion labels,^{52,53} or consolidated time blocks by eating occasions,^{9,10} limits the bias that researchers and study participants may place on the names assigned to eating occasions throughout the day. A limitation was the examination of all days in the analysis rather than separate examination of weekdays and weekend days. However, this issue could be considered in future analyses with a larger sample size. Further, the results are based on the times of eating for only one day and conclusions are applicable to the population rather than to individuals.

Conclusions

Temporal dietary patterns are associated with differences in daily diet quality. Groups of individuals that reported proportionally equivalent energy consumed during three evenly spaced eating occasions throughout a day exhibited a higher quality diet based on the 2005 Dietary Guidelines for Americans compared with the groups of individuals that consumed

energy in other patterns over the 24-hour day. The incorporation of multiple aspects of dietary intake such as time, frequency, and proportional energy consumed, may be evaluated to determine links to daily diet quality and enhance knowledge of the complicated interplay of time and dietary intake.

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Figure 1.
Temporal dietary patterns of the largest daily energy consumption event for clusters (C=4)
of US adults 20-65 years from the 1999-2004 National Health and Nutrition Examination
Survey (n=9,326)

Figure 2.
Temporal dietary patterns of the second largest daily energy consumption event for clusters (C=4) of US adults 20-65 years from the 1999-2004 National Health and Nutrition Examination Survey ($n=9,326$)

Table 1

Characteristics of clusters representing temporal dietary patterns of US adults 20 to 65 years as drawn from the 1999-2004 National Health and Nutrition Examination Survey ($n=9,326$)

Characteristics	Cluster 1 $n(\%)^a$	Cluster 2 $n(\%)^a$	Cluster 3 $n(\%)^a$	Cluster 4 $n(\%)^a$	Total n	χ^2 P -value ^b
Total	3,789(40.6)	2,622(28.1)	2,020(21.7)	895(9.6)	9,326	
Survey Year						
1999-2000	1,138(30)	856(32.5)	639(31.6)	299(33.4)	2,932	
2001-2002	1,401(37)	939(35.7)	714(35.3)	311(34.7)	3,365	
2003-2004	1,250(33)	827(31.4)	667(33.0)	285(31.8)	3,029	0.17
Sex						
Male	1,882(49.7)	1,319(50.3)	1,012(50)	469(52.4)	4,682	
Female	1,907(50.3)	1,303(49.7)	1,008(49.9)	426(47.6)	4,644	0.37
Race/Ethnicity						
NHW ^c	1,872(49.4)	1,256(47.9)	807(40)	358(40)	4,293	
NHB ^d	742(19.6)	548(20.9)	448(22.2)	243(27.2)	1,981	
MA ^e	883(23.3)	568(21.7)	577(28.6)	205(22.9)	2,233	
O ^f	292(7.7)	250(9.5)	188(9.3)	89(9.9)	819	<0.0001
Age group						
20-34 years	1,213(32)	816(31.1)	696(34.5)	289(32.3)	3,014	
35-49 years	1,300(34.3)	958(36.5)	686(34)	310(34.6)	3,254	
50-65 years	1,276(33.7)	848(32.3)	638(31.6)	296(33.1)	3,058	<0.01
Household PIR ^g						
0-0.99	609(17.5)	410(17)	380(20.2)	202(25.1)	1,601	
1.00-1.99	821(23.6)	542(22.4)	491(26.1)	192(23.9)	2,046	
2.00-2.99	546(15.7)	366(15.1)	293(15.6)	104(12.9)	1,309	
3.00-3.99	409(11.8)	326(13.5)	228(12.1)	107(13.3)	1,070	
4.00-4.99	361(10.4)	249(10.3)	178(9.5)	62(7.7)	850	
>5.00	731(21)	525(21.7)	308(16.4)	138(17.1)	1,702	<0.001
BMI ^h						
Underweight	68(1.8)	42(1.6)	21(1.1)	15(1.7)	146	
Normal weight	1,232(33)	753(29.3)	589(29.5)	226(25.7)	2,800	
Overweight	1,263(33.9)	882(34.3)	701(35.1)	326(37)	3,172	
Obese	1,164(31.2)	891(34.7)	688(34.4)	313(35.6)	3,056	<0.0001

^aTotal numbers do not always add to sample size due to missing values.

^bRao Scott F-adjusted χ^2 P -value is a goodness-of-fit, one-sided test; Statistical significance is indicated when $P < 0.05$. Analyses were adjusted for clustering and stratification. Sample weights were appropriately constructed and applied to the analysis as directed by National Center for Health Statistics. Weights were rescaled so that the sum of the weights matched the survey population at the midpoint of the six years covering 1999-2004.

^cNon-Hispanic white

^dNon-Hispanic black

^eMexican American

^fOther Hispanic & other race/ethnicity

^gPIR=Poverty-income ratio

^hBMI=Body mass index; categories were defined as per the World Health Organization^{28, 29}

Table 2

Mean total Healthy Eating Index-2005 (HEI-2005) scores and covariate adjusted regression model results for clusters representing temporal dietary patterns of US adults 20 to 65 years as drawn from the 1999-2004 National Health and National Examination Survey^a

	<i>n</i> (%)	Mean (SEM)	Total HEI-2005 Score ^b					
			β (SE) ^c	<i>P</i> -value ^d	β (SE) ^c	<i>P</i> -value ^d	β (SE) ^c	<i>P</i> -value ^d
Adjusted Models ^e			Compared to: Cluster 2		Cluster 3		Cluster 4	
Cluster 1	3,789 (40.6)	51.4 (0.3)	2.3(0.5)	<0.0001	3.3(0.5)	<0.0001	5.9(0.7)	<0.0001
Cluster 2	2,622 (28.1)	49.4 (0.5)			1.0(0.6)	0.08	3.6(0.8)	<0.0001
Cluster 3	2,020 (21.7)	47.7 (0.5)					2.6(0.7)	<0.001
Cluster 4	895 (9.6)	45.4 (0.6)						

^aSimple regression model results are not shown but differences in the mean total HEI-2005 scores were present among all clusters at $P < 0.05/6$ (Bonferroni type adjustment for multiple comparisons of cluster total HEI-2005 score means).

^bThe HEI-2005 represents adherence to the 2005 Dietary Guidelines for Americans with a high score representing high adherence and a low score representing low adherence on a scale of 0 to 100.

^c β represents difference between mean total HEI-2005 score of cluster and reference cluster.

^d*P*-values are 2 sided; Statistical significance is indicated when $P < 0.05/6$; Estimates were adjusted for clustering and stratification. Sample weights were appropriately constructed and applied to the analysis as directed by the National Center for Health Statistics. Weights were rescaled so that the sum of the weights matched the survey population at the midpoint of the six years covering 1999-2004.

^eModels were adjusted for survey year, sex, age, race/ethnicity, household poverty-income ratio, and body mass index.