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BMJ Open

The Effects of Food Items and Related Nutrients on Metabolic Syndrome Using Multilevel Modeling.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-020642
Article Type:	Research
Date Submitted by the Author:	14-Nov-2017
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Keywords:	Metabolic syndrome (MetS), ; Tehran Lipid and Glucose Study (TLGS), FFQ, generalized linear mixed model (GLIMMIX)

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Title: The Effects of Food Items and Related Nutrients on Metabolic Syndrome Using Multilevel Modeling.

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Word count: 2985

Abstract

Objectives: Diet and nutrition may play an important role in the etiology of metabolic syndrome. Most studies of the effects of food intake on metabolic syndrome (MetS) based on conventional analyses have investigated only a limited number of food items. We examined the concurrent effects of numerous foods and related nutrients on the incidence of metabolic syndrome using multilevel modeling.

Design: prospective cohort study.

Setting: This study was conducted in the setting of Tehran Lipid and Glucose Study .We compared two statistical approaches. The first method used a Bayesian multilevel model fitted with GLIMMIX, whereas the second method used multiple logistic regression with two types of variable selection.
Participants: This prospective study was conducted on 3616 healthy adults, aged ≥20 years.
primary and secondary outcome measures: Metabolic syndrome was considered as primary outcome.
Results: The mean (standard deviation (SD)) age of the participants and median follow-up time was 40.6 (12.6) years and 24.6 months, respectively. The incidence rate of MetS was 821 (95%CI: 757-890) cases per 10000 person-years. The multilevel approach gave results that were more stable and realistic compared to the model that forced in all variables. For example, the confidence limits for the effects of four foods comparing the multilevel and conventional model were: noodle soup [(0.67-2.14) vs. (0.65-5.64)], beans [(0.5-1.85) vs. (0.03-11.41)], turnip [(0.68-2.23) vs. (0.82-7.52)] and eggplant [(0.51-2.00) vs. (0.152×10-6-768×1012)]. For a majority of the foods, the multilevel approach gave more narrow confidence limits than either of the conventional approaches, and hence the best precision.
Conclusions: Despite the complexity of the multilevel model, it is recommended for the analysis of multiple nutritional exposures that are highly correlated.
Keywords: Metabolic syndrome (MetS); Tehran Lipid and Glucose Study (TLGS); FFQ; generalized linear mixed model (GLIMMIX).

Strengths and limitations of this study:

- The paper illustrates Bayesian multilevel approach for handling high collinearity between exposures in a non-technical level.
- All estimations were precise.
- The results based on Bayesian multi-level model, did not biased due to sparse data problem.
- The most important limitation of this study were the well-known disadvantages of using a FFQ to assess food intake.
- FFQ has limitations in determining dietary patterns, since it encompasses a long list of foods consumed during the past year.
- Also, the FFQ underestimates the consumption of proteins and carbohydrates, so the possibility of measurement error and recall bias that can distort the results exist.

Introduction

Metabolic syndrome (MetS) is the clustering of at least three of the five following medical conditions: central/abdominal obesity, hypertension, elevated blood sugar, elevated triglyceride levels and reduced HDL levels (1). MetS is associated with the risk of developing cardiovascular disease and diabetes. According to the World Health Organization (WHO), approximately 20 – 25 percent of the world's adult population are affected with MetS (1). MetS is considered a multi-factorial disease, in which nutritional exposures and diet are major contributing factors.

Thus far, the effects of different foods on MetS have been investigated in many studies using conventional analyses such as multiple logistic regression (2-6).

In most of these studies, only a limited number of food items have been investigated. This ignores the information we have about the effects of food through their nutrient contents. On the other hand, a conventional model that includes only nutrients erroneously assumes that there are no unmeasured nutrients or interactions among modeled nutrients and all food effects are transmitted through the measured nutrients (7-9). The simultaneous effects of numerous food items and related nutrients cannot be studied with conventional models due to the high collinearity. Another limitation is that the estimates from conventional models including all food items or all nutrients may suffer from sparse data bias (10, 11).

Bayesian multilevel models can be used to deal with the aforementioned problems, providing improvement in the precision and accuracy of estimates of effect (12). Therefore, our objective was to examine the simultaneous effects of different food items and related nutrients on the incidence of MetS in healthy adults using multilevel models.

Materials and Methods: This prospective study is part of the Tehran Lipid and Glucose Study' (TLGS) [13]. The TLGS began in 1998 and was conducted on 15005 persons aged 3 to 63 years old from Tehran's District 13. We used the data collected in the fourth (2008-2011) and fifth (2011- 2014) follow-up examinations. Data related to dietary intakes and other covariates were collected from the fourth phase, and new MetS cases were identified, from the fifth phase, which was considered as the follow-up phase (Figure 1).

Target population: We selected 3616 adults aged ≥20 years who were not affected with MetS at the fourth follow-up examination (2008) and who had dietary information (Flowchart 1). The new MetS cases were 590 persons.

Inclusion criteria: Those who were eligible for the study included adults aged ≥20 years who had been followed up from the fourth to the fifth phase, and who had the following criteria: no history of chronic diseases (diabetes, stroke, thyroid problems and cancer); not following any specific dietary regime (such as a weight loss diet and the intake of fewer than 800 kcal or greater than 4000 kcal per day); and not being affected with MetS.

Measurement of outcome: MetS was defined according to the recent consensus guidelines [14] as having at least three of the following criteria: 1) abdominal obesity (waist circumference > 90cm in both genders) (15); 2) lowered serum HDL levels (lower than 40mg/dl in men and 50 mg/dl in women or the consumption of HDL–elevating drugs); 3) hypertension (a systolic BP≥130 mmHg or a diastolic BP≥85 mmHg or the consumption of antihypertensive drugs); 4) hyperglycemia (a fasting blood glucose (FBS)≥100 mg/dl or the consumption of hypoglycemic drugs); and 5) hypertriglyceridemia (a serum triglyceride level≥150mg/dl or the consumption of triglyceride–lowering drugs).

Measurement of exposure: Nutritional data on the participants' dietary intake were collected using a semi-quantitative food frequency questionnaire (FFQ), which consists of 147 food items. Several nutritionists who had been trained in the field completed the questionnaires through face-to-face interviews. During the interview, the average size of each of the FFQ food items (which is equal to one food serving) was described to each participant, and then s/he was asked about the number of times each item was taken in the previous year. The validity and reliability of the FFQ has been already assessed through several studies in Iran and was found to be acceptable [16, 17]. The consumption frequency of each food item in the previous year was assessed in the form of days, weeks, months and/or year, and then, using home scale guides, the amount consumed of each item was transformed into grams per day. The amount of intake of energy and nutrients were determined using the food composition table.

Other measured variables:

Other measured covariates included: weight, height, age, gender, marital status, history of hospitalization during previous three months, history of cancer, education (primary, intermediate, high school and high school graduate, academic education) and tobacco use (never smoked, previously smoked, currently smoking). There data were collected using a general information questionnaire interview administered by a nutritionist.

Data analysis

We estimated the effects of food items and nutrients on MetS using multilevel and conventional analyses. The GLIMMIX software was used for the multilevel analysis. Logistic regression (LR) with two types of variable selection (stepwise-backward selection or, alternatively, including all variables in the model) was applied in the conventional analysis approach.

In the multilevel approach, we investigated the concurrent effects on MetS of 95 food items (listed in Table 2) and 12 nutrients (carbohydrates, protein, total fat, monounsaturated fatty acids, carotenoids, calcium, folate, magnesium, zinc, fiber, glucose, and fructose), adjusted for nine covariates (age, gender, cancer history, hospitalization status, educational status, body mass index, marital status, smoking history, and calories).

In the first conventional analysis (full model), 95 food items and nine covariates were forced into the model. Because of the high correlation between food items and nutrients resulting in the non-convergence of maximum likelihood estimates, the effects of nutrients were not investigated in the conventional analysis.

In the conventional analysis using stepwise backward selection, the alpha level for selection of food items was set at 0.2 and all nine confounders were forced into the model. Seventy-seven (77) food items were removed at this stage, leaving 18 foods.

In all three models, the following six food items were removed from the models due to high collinearity between variables (Pearson correlation≥0.4), retaining the food with a statistically stronger effect (specified in parentheses) in the final analysis: Jam (sugar),plum (peach), lemon juice (lemon), apple juice (apple), orange juice (orange), and cooked vegetables (cooked carrots). Moreover, in all the models, 46 food items (data available upon request) were excluded from our analyses because it seemed unlikely that they would have considerable dietary effects on MetS. Thus 95 [147-(6+46)] food items were retained in the analysis.

To interpret the effects of foods on MetS more easily, each food item variable was transformed from 'grams' to specified servings using valid references based on daily servings (18).

Data analysis was done with Stata 11 (StataCorp, College Station, TX, USA) for the conventional analysis and SAS 9.2 for the Bayesian multilevel approach. The parameters of the LR and multilevel models were estimated using maximum likelihood and shrinkage (penalized likelihood) methods, respectively. To compare the precision of estimates, we calculated the difference in confidence limits for odds ratios of foods in the logarithm scale (log upper odds ratio minus log lower odds ratio).

Structure of the multilevel model

We can write the first stage model (1) as: $\text{logit}(p \mid X, W) = \alpha + X\beta + W\gamma$

In this model, *p* is risk of MetS, ***X*** is the matrix of food items information, ***W*** is the matrix of other potential confounders, and **β** (β1, . . ., β95) is the vector of logistic regression coefficients corresponding to the 95 foods items. The first stage model is also the LR for the conventional analysis.

Second Stage (2): $\boldsymbol{\beta}_j = \pi_1 z_{1j} + \pi_2 z_{2j} + \pi_p z_{pj} + \delta_j = \boldsymbol{z_j \pi} + \boldsymbol{\delta}_j$

$$z_j = (z_{1j}, z_{2j}, \dots z_p)$$

$$\boldsymbol{\delta}_j \sim MVN\,(0, \tau_j)$$

156 Where $\boldsymbol{\pi}$ is the vector of coefficients of second-stage covariates for nutrients that may contribute to dietary effects on MetS. These second stage covariates (***Z***) include nutrients carbohydrates, protein, total fat, monounsaturated fatty acids, carotenoids, calcium, folate, magnesium, zinc, fiber, glucose, and fructose. The quantity δ_j is the residual effect of food item *j*, which is assumed to be an independent normal random variable with zero mean and standard deviation τ_j. Following Witte and Greenland [X], we specified a fixed value of tau to improve estimation convergence. Based on a similar study [12, 19), we set the standard deviation τ_j equal to 0.35 for all food items. This corresponds to our having 95% certainty that the odds ratio for the residual effects of foods (per serving of each food) lies between 0.5 and 2.0. The second stage can be interpreted as the prior distribution for the beta coefficients in the multilevel method. The second-stage model shrinks the ordinary estimates toward each other when they have similar levels of nutrients.

166 Models 1 and 2 can be combined into a 'mixed-effects' model (3):

$$logit\ (p|\boldsymbol{X},\ \boldsymbol{Z},\boldsymbol{W}) = (\alpha + \boldsymbol{X}(\boldsymbol{Z\pi} + \boldsymbol{\delta}) + \boldsymbol{W\gamma}) = \alpha + \boldsymbol{XZ\pi} + \mathbf{X\delta} + \boldsymbol{W\gamma}$$

167 In this model, $\boldsymbol{\pi}$ and $\boldsymbol{\gamma}$ are treated as vectors of fixed coefficients, and δ is treated as a vector of random coefficients with mean zero and variance 0.35^2=0.1225. Hence one interpretation is that the multi-level model includes X-Z interactions, which allow the effects of X on MetS to be similar when there is a similar nutrient level in the food items.

171 For estimating the fixed and random effects in the multilevel model, the Mixed-Model Equations Solution Matrix (MMEQSOl) from SAS GLIMMIX output was used. MMEQSOl contains fixed $\hat{\pi}$, random $\hat{\delta}$, and covariate $\hat{\gamma}$ estimates and their respective estimated covariance matrices. In our study, the MMEQSOl was a 117*117 (95 foods+ 12 nutrients+ 9 covarites+1 intercept) matrix (appendix 1).

175 **Results**

176 The mean (standard deviation **(**SD) age of participants and median follow-up time were 40.6 (12.6) years and 24.6 months, respectively. The total incidence rate was 82.2 (95%CI: (75.8-89.1) per 10000 person-years. The incidence was higher in males than in females (125.6 vs. 65.3 per 10000 person-years, p<0.001). In both genders, those affected with MetS were older (p<0.001). Also, the percentages of married individuals and those who had experienced a heart attack was higher among those with MetS (p<0.001) (Table 1).

181 **Conventional analysis**

The adjusted odds ratios (95% CI) between food intakes and other covariates on MetS using logistic regression (LR) with two types of variable selection methods, stepwise backward selection versus the full model, are reported in Table 2. The conventional analysis is described in detail elsewhere [20).

Full model (LR with all food variables in the model)

Based on this model, two food items were associated with MetS: banana (OR= 1.38, 95%CI: 1.05-1.83; p=0.02), and grapes (OR=1.14, 95%CI: 1.01-1.29, P=0.03). Two other food items were weakly associated with MetS as well: beef (OR=1.71, 95%CI: 0.95-3.08, p=0.08), and chicken (OR=1.24, 95%CI: 0.99-1.56, P=0.06). On the other hand, there was weak evidence of an inverse association of lamb meat (OR=0.44, 95%CI: 0.17-1.12, p=0.09) with MetS.

LR via Backward Selection Method

As mentioned in the methods section, only 18 foods remained in the final model. Based on this reduced model, grapes (OR: 1.11, 95% CI:-1.01-1.29, p=0.03) and banana (OR: 1.37, 95% CI 1.05-1.78, p=0.02) were associated with for MetS. Also, there was some evidence that rice (OR=1.11, 95%CI: 0.99-1.2, p=0.06), turnip (OR=2.41, 95% CI: 0.77-6.69, p=0.09), and seeds (OR=1.32, 95%CI: 0.99-1.77, p=0.053) were positively associated with MetS. On the other hand, lamb meat seemed to be inversely associated with MetS (OR: 0.40, 95% CI: 0.16-0.99, p=0.05).

Multi-level Bayesian Analysis via the GLIMMIX

Based on this model, grapes (OR= 1.14, 95% CI: 1.01-1.27, p=0.03) and banana (OR=1.32, 95%CI: 1.01-1.74, p=0.05) were positively associated with MetS. There was also some evidence that fructose was positively associated with the risk for MetS (OR=1.84, 95% CI: 0.97-3.51, p=0.06) (Table 2).

Upon comparing the three models, 15 (83.3%) of the odds ratio estimates were the smallest (toward the null) in the multilevel model which is unsurprising given that the mean of the residual effects of foods (δ_j) was pre-specified as zero, so the odds ratio estimates underwent shrinkage toward the null value. In the remaining three foods (16.6%), the odds ratio estimates were very similar between models.

Discussion

Although diet may play role in etiology of MetS, most previous studies have only looked at a limited number of food items because of limitations of conventional modeling approaches. (7-9). In other hand, multi-level models and shrinkage estimators are known to give lower prediction error and providing improvement in the precision and accuracy of estimates of effect (12). We used Bayesian multilevel models to study the simultaneous effects of different food items and related nutrients on the incidence of MetS and compared it to conventional models. We used three models (backward selection and full conventional model, and multilevel model) from two analytical approaches to estimate the adjusted effects of food items and nutrients related to MetS among adults in the Tehran and Lipid Glucose Study.

Banana and grapes were the only items that were associated with MetS in all three models. However, upon stratifying by diabetes status, the effects were weaker in the non-diabetes group. Furthermore, because of the small sample size of the diabetic group (37 new cases of MetS in the 328-populated diabetics group: 0.11 case per event), model fitting in this group did not converge.

The histogram of regression coefficients of dietary items indicates the penalized likelihood estimates (from GLIMMIX) are much less dispersed than the maximum likelihood estimates in conventional analyses (Figure 2). Also GLIMMIX has a better goodness of fit than the conventional models: The Akaike Information Criterions (AICs) for backward selection method, full model and GLIMMIX were 29153.6, 27913.9 and 18356.1, respectively.

The largest odds ratio estimates were observed in the full-model so that the odds ratio estimates in GLIMMIX were more similar to the backward rather than to the full model. For 10 (55.5%) of 18 common odds ratios, the GLIMMIX had the narrowest confidence limits and the highest precision. For seven (38.8%) of odds ratios, the backward model had the best precision. In one (5%), there was similar precision. The full model had the best precision in only one estimate. Although in the backward method only 18 variables remained in the final model, GLIMMIX outperformed backward method in terms of precision of the odds ratio estimates.

In the 77 (95-18) remaining food items that were common in the GLIMMIX and full model, multilevel modeling exhibited better precision (60 (78%) vs. 15(0.20%)). In two (2%) of odds ratios, both models exhibited a similar status.

In the multilevel model, the confidence limits for four odds ratios (that were extreme) were stable and realistic as follows; noodle soup ([0.67-2.14] vs. [0.65-5.64]), beans ([0.5-1.85] vs. [0.03-11.41]), turnip ([0.68-2.23] vs. [0.82-7.52]). In the conventional analysis (LR-full model), the estimation for eggplant was strongly affected by the sparse data bias [10, 11], (OR= 109396, 95% CI= 0.152×10-6-768×1012), but this implausible and imprecise estimation was balanced in the multilevel model (OR=1.01, 95% CI= 0.51-2.00). This balancing of extreme estimates has been shown in earlier studies (12, 19).

The most significant limitation of the stepwise backward selection method was the deletion of some variables from the model, which assumes they have no effect with full certainty. As mentioned in the backward method, 77 variables were removed from the final model; such variable selection leads to downward bias in the p-values and standard errors for the reaming variables in the model (21).

Various studies (22, 23) have shown the protective effects of vegetables and fruits on MetS. These substances exert their protective effects through beneficial combinations such as antioxidants, fiber, potassium and other herbal chemicals, and through reducing the concentration of CRP (C-Reactive Protein) (24). But because of the low power of the study, we did not detect any associations for such fruits & vegetables, like kiwifruit, watermelon, apple, cherry, plum, tangerine, dates, nectarine, lemon, tomato, celery, raw onions, cooked cabbage, lettuce, and potatoes.

Moreover, we detected a weak association between fructose and MetS. Some studies (25-28) have shown that the consumption of foods and beverages that are high in fructose facilitate dyslipidemia (increased triglycerides and LDL and decreased HDL). As previously mentioned, hyperlipidemia is considered as one of the components of metabolic syndrome, hence this finding is consistent with earlier studies.

Esmailzadeh, Maras and Ruidavets (29-31) have shown the protective effect of whole grains on the incidence of MetS, though we did not detect such an association. However, that study only assessed a limited number of foods, and the results may be subject to bias.

The most important limitation of this study were the well-known disadvantages of using a FFQ to assess food intake. Several studies have shown that the FFQ has limitations in determining dietary patterns, since it encompasses a long list of foods consumed during the past year. Also, the FFQ underestimates the consumption of proteins and carbohydrates, so the possibility of measurement error and recall bias that can distort the results exist (32-34).

There was also an issue with limited sample size (dimensionality and non-convergence problem). According to a rule of thumb in statistics(35), logistic models require a minimum of 10 events per predictor variable. As we should estimate the effect of 104 variables (95 food intakes plus nine confounders) this means we require 1040 cases while in our study only 590 new cases of MetS developed. However this problem is partly resolved in the Bayesian multilevel approach.

In conclusion, multilevel models present more precise and sensible estimates of association compared to the conventional models, and they can reduce sparse data bias. Despite the complexity of the semi-Bayes model, it is recommended for the analysis of multiple, correlated and multi-level nutritional exposures.

Ethical approval: Shahid Beheshti University of Medical Sciences (SUMS)/ Research Ethics Board.

Acknowledgments

We thank John Witte for his helpful comments on an earlier draft of this paper. We would like to extend our gratitude to the authorities of the 'Research Institute for Endocrine Sciences' at Shahid Beheshti University of Medical Sciences for sharing their valuable data with us. Moreover, we are grateful to all the participants for lending us their valuable time. designed research (project conception, development of overall research plan, and study oversight); The authors also have no conflicts of interest and have no involvement that might raise the question of bias in the results reported here. Authors' Contribution:(Z.Ch conducted research, Z.Ch and N.Mo provided essential reagents or provided essential materials, Z.Ch, S N, M.M and P.M analyzed data or performed statistical analysis. Ch, S N, M.M, P.M and L.Mc wrote paper, Ch, S N, M.M, P.M, N.Ma, N.Mo and L.Mc had primary responsibility for final content; Z. Ch had responsibility for all parts of the manuscript).

Funding: This article has been extracted from the first author's Ph.D. thesis (code: 912-112-8002) and was supported by Tehran University of Medical Sciences (TUMS).

Competing interests: None declared.

Data sharing statement: Data are not available for sharing.

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Table 1. Comparison of baseline characteristics of subjects who did and did not develop incident MetS after three years of follow-up.

Variables	**Men**			**Women**			**All**		
	Non-MetS (N=1082)	MetS (N=291)	P-v*	Non-MetS (N=1944)	MetS (N=299)	P-v	Non-MetS (N=3026)	MetS (N=590)	P-v
Age (years)	41.60	43.77	0.01	38.87	47.06	<0.001	39.84	45.43	<0.001
BMI(kg/m2)	26.31	30.67	<0.001	25.41	28.08	<0.001	25.98	29.39	<0.001
Marital status (%)			<0.001			<0.001			<0.001
Married	75.44	86.94		77.28	87.29		75.44	87.12	
Single/Divorced/Widowed	24.65	13.06		22.72	12.71		24.56	12.88	
HMI (%)	0.09	0.69	0.02	0.00	0.33	0.01	0.03	0.51	<0.001
FHDM (%)	6.76	4.48	0.15	11.23	8.03	0.24	9.63	6.28	0.02
Smoking (%)			0.89			0.69			0.13
Never	78.33	78.69		96.55	96.99		90.03	87.97	
Current/Past	21.67	21.31		3.45	3.01		9.97	12.03	
Education Level (%)			0.77			<0.001			<0.001
Higher than diploma	41.77	42.61		42.03	22.41		41.94	32.37	
Diploma/below diploma	51.57	51.89		50.82	64.21		51.09	58.14	
Illiterate/Primary School	6.65	5.50		7.15	13.38		6.67	9.49	
Cancer history (%)	0.19	0.34	0.60	0.52	1.34	0.09	0.40	0.85	0.14
Hospitalization (%)	12.04	11.36	0.90	6.25	15.87	0.01	7.66	14.02	0.03

*: the P-value of T-test and Chi-Squared Test; FBS: fasting Blood Sugar; BMI: body mass index; DM: diabetes mellitus; HMI: history of myocardial infraction disease; FHDM: family history of diabetes mellitus.

Table 2: the effects of food items, nutrients and other covariates on MetS from conventional and multilevel (Semi-Bayes) analyses

Variables*	Comparison group	Multiple Logistic Regression Model								
		GLIMMIX			Backward Selection			Full Model		
		OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Gender	*Female/male*	0.47	0.38, 0.59	**<0.01**	0.47	0.36, 0.58	**<0.01**	0.46	0.36, 0.58	**<0.01**
Age	*Per 5 years*	1.16	1.11, 1.21	**<0.01**	1.16	1.11, 1.22	**<0.01**	1.16	1.11, 1.22	**<0.01**
Energy	*Per kcal*	1.02	0.98, 1.03	0.85	0.99	1, 1.01	0.10	0.98	1, 1.01	0.53
Cancer History	*Yes vs. no*	2.02	0.59, 6.95	0.26	1.90	0.54, 6.68	0.32	2.00	0.54, 6.68	0.29
Hospitalization	*Yes vs. no*	1.85	0.93, 3.65	0.08	1.96	0.98, 3.90	0.05	1.85	0.98, 3.90	0.09
Smoking	*Yes vs. no*	1.23	0.86, 1.76	0.25	1.23	0.86, 1.77	0.25	1.27	0.86, 1.77	0.21
Body Mass Index	*(kg/m^2)*	1.19	1.17, 1.22	**<0.01**	1.19	1.16, 1.22	**<0.01**	1.19	1.16, 1.22	**<0.01**
Education	*Per one degree*	1.34	1.02, 1.76	**0.04**	1.12	0.99, 1.27	0.07	1.34	0.99, 1.27	**0.04**
Marriage	*married vs. single*	1.13	1.01, 1.28	**0.04**	1.34	1.2, 1.78	**0.04**	1.15	1.2, 1.78	**0.05**
Barbari *(Type of Bread)*	*1/4*	1.03	0.67, 1.58	0.89	deleted	-		1.01	0.36, 0.58	0.84
Sangak *(Type of Bread)*	*1/4*	1.00	0.79, 1.26	0.97	deleted	-		1.04	1.11, 1.22	0.71
Taftun *(Type of Bread)*	*1/2*	1.03	0.73, 1.45	0.88	deleted	-		0.97	0.99, 1	0.72
Baguette	*1/2*	0.98	0.79, 1.21	0.83	deleted	-		0.64	0.56, 7.21	0.40
Lavash *(Type of Bread)*	*1*	0.84	0.48, 1.48	0.55	deleted	-		1.07	0.91, 3.76	0.62
Cooked Rice	*1 cup*	1.05	0.83, 1.34	0.66	1.11	0.99, 1.24	0.057	1.10	0.87, 1.84	0.18
Pasta	*1 cup*	1.20	0.77, 1.87	0.43	deleted	-		1.43	1.17, 1.22	0.23
Potato	*1*	0.89	0.54, 1.46	0.65	deleted	-		0.76	0.35, 1.62	0.47
Fried Potato	*10 strip*	1.04	0.78, 1.39	0.79	deleted	-		1.07	0.77, 1.47	0.70
Noodle Soup	*¾ cup*	1.20	0.67, 2.14	0.54	deleted	-		1.91	0.65, 5.64	0.24
Noodle Ash *(Type of soup)*	*1 cup*	0.99	0.57, 1.73	0.98	deleted	-		0.93	0.36, 2.44	0.88
Cracker	*1*	0.94	0.73, 1.22	0.64	deleted	-		0.95	0.71, 1.27	0.73
Corn	*¼ cup*	1.03	0.76, 1.4	0.84	deleted	-		1.02	0.72, 1.45	0.89
Barley	*¼ cup*	1.13	0.74, 1.73	0.58	deleted	-		1.17	0.65, 2.08	0.60
Lentil	*½ cup*	1.10	0.76, 1.59	0.62	deleted	-		1.23	0.86, 1.75	0.26
Beans	*½ cup*	1.06	0.64, 1.75	0.83	deleted	-		1.03	0.45, 2.36	0.95
Pea	*½ cup*	1.25	0.77, 2.04	0.37	1.66	0.88, 3.09	0.11	1.55	0.71, 3.38	0.27

Variables*	Comparison group	Multiple Logistic Regression Model								
		GLIMMIX			Backward Selection			Full Model		
		OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Bean	*2 cup*	0.96	0.5, 1.85	0.91	deleted	-		0.55	0.03, 1.41	0.70
Soya	*½ cup*	0.80	0.48, 1.3	0.36	deleted	-		0.67	0.3, 1.51	0.34
Cotyledon	*1 cup*	1.02	0.57, 1.83	0.96	deleted	-		0.97	0.29, 3.27	0.96
Lamb Meat	*2 oz*	0.77	0.45, 1.33	0.34	0.40	0.16, 0.99	0.05	0.44	0.17, 1.12	0.09
Beef	*2 oz*	1.39	0.88, 2.19	0.16	1.54	0.88, 2.71	0.13	1.71	0.95, 3.08	0.08
Ground beef	*2 oz*	0.88	0.53, 1.47	0.63	deleted	-		0.79	0.35, 1.76	0.56
Chicken	*3.5 oz*	1.24	0.87, 1.78	0.24	1.19	0.96, 1.48	0.10	1.24	0.99, 1.56	0.06
Fish	*3.5 oz*	1.02	0.77, 1.34	0.90	deleted	-		1.00	0.87, 1.14	0.97
Canned Fish	*3.5 oz*	0.98	0.53, 1.8	0.94	deleted	-		0.91	0.23, 3.53	0.89
Sausage	*100 gr*	0.88	0.46, 1.7	0.71	deleted	-		0.26	0.02, 3.15	0.29
Egg	*1*	1.00	1, 1	0.78	deleted	-		1.00	1, 1	0.79
Pizza	*100 gr*	0.96	0.62, 1.48	0.85	deleted	-		0.94	0.55, 1.62	0.83
Low-Fat Milk	*1 cup*	1.00	0.8, 1.26	0.99	deleted	-		1.04	0.84, 1.27	0.74
Whole-Fat Milk	*1 cup*	0.97	0.77, 1.21	0.77	deleted	-		1.00	0.81, 1.23	0.98
Chocolate Milk	*1 cup*	1.10	0.75, 1.63	0.62	deleted	-		1.22	0.77, 1.94	0.39
Yogurt	*½ cup*	1.08	0.84, 1.39	0.56	deleted	-		1.12	0.88, 1.43	0.34
Strain Yogurt	*1 cup*	0.93	0.76, 1.13	0.47	deleted	-		0.96	0.83, 1.11	0.58
Whole Fat Yogurt	*1 cup*	0.90	0.71, 1.14	0.37	deleted	-		0.91	0.73-1.12	0.37
Cheese	*1 oz*	1.06	0.9, 1.25	0.47	1.10	0.96, 1.27	0.15	1.09	0.93-1.28	0.26
Whole-Fat Cheese	*2 oz*	0.85	0.5, 1.43	0.53	deleted	-		0.63	0.26-1.52	0.31
Yogurt Drink	*1 cup*	1.08	0.77, 1.51	0.65	deleted	-		1.15	0.82, 1.61	0.43
Traditional Ice Cream	*1 cup*	1.04	0.64, 1.7	0.86	deleted	,		1.10	0.54-2.25	0.79
Butter	*1 cup*	0.92	0.6, 1.42	0.72	deleted	-		0.85	0.49-1.46	0.56
Shredded Lettuce	*1.5 cup*	0.84	0.56, 1.26	0.39	deleted			0.75	0.44-1.29	0.30
Tomato	*1*	0.99	0.8, 1.21	0.91	0.89	0.77, 1.2	0.12	0.89	0.75, 1.05	0.18
Cucumbers	*1*	1.05	0.91, 1.21	0.52	deleted	-		1.06	0.9, 1.24	0.48
Vegetables	*1.5 cup*	1.24	0.72, 2.11	0.44	deleted	-		1.62	0.67, 3.9	0.28
Eggplant	*3.5 oz*	1.01	0.51, 2	0.98	deleted	-		109396	0, 79*10^15	0.41

Variables*	Comparison group	Multiple Logistic Regression Model								
		GLIMMIX			Backward Selection			Full Model		
		OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Cooked Celery	*1/3 cup*	0.95	0.52, 1.76	0.88	deleted	-		0.71	0.16, 3.11	0.65
Green Peas Cooked	*½ cup*	0.82	0.45, 1.47	0.50	0.41	0.12, 1.44	0.14	0.38	0.09, 1.58	0.18
Green Beans Cooked	*¼ cup*	0.98	0.64, 1.5	0.93	deleted	-		1.11	0.61, 2.02	0.73
Raw Carrots	*1*	1.01	0.67, 1.53	0.95	deleted	-		0.87	0.56, 1.35	0.54
Cooked Carrots	*½ cup*	1.04	0.61, 1.78	0.88	deleted	-		0.81	0.39, 1.68	0.57
Raw Onion	*1/3 cup*	0.94	0.69, 1.28	0.70	deleted	-		0.88	0.61, 1.28	0.50
Fried Onions	*½ cup*	1.06	0.73, 1.53	0.78	deleted	-		1.03	0.65, 1.62	0.91
Cabbage	*½ cup*	0.91	0.72, 1.17	0.48	deleted	-		0.90	0.68, 1.19	0.47
Green Pepper	*½ cup*	1.06	0.68, 1.66	0.80	deleted	-		1.05	0.57, 1.93	0.87
Cooked Spinach	*½ cup*	1.09	0.62, 1.91	0.76	deleted	-		0.90	0.36, 2.25	0.82
Turnip	*2/3 cup*	1.23	0.68, 2.23	0.49	2.41	0.77, 6.69	0.09	2.48	0.82, 7.52	0.11
Ketchup	*1 sp*	0.97	0.64, 1.46	0.88	deleted	-		0.91	0.54, 1.53	0.73
Pickle	*2 sp*	1.04	0.88, 1.23	0.66	deleted	-		1.05	0.91, 1.22	0.51
Cantaloupe	*1*	1.10	0.81, 1.51	0.54	deleted	-		1.07	0.75, 1.54	0.70
Melon	*1*	1.00	0.69, 1.45	0.98	deleted	-		1.01	0.63, 1.63	0.96
Watermelon	*¾ cup*	0.98	0.74, 1.3	0.91	deleted	-		0.90	0.71, 1.14	0.38
Pear	*1*	1.04	0.72, 1.51	0.81	deleted	-		1.05	0.66, 1.67	0.84
Cherry	*15*	0.95	0.83, 1.09	0.44	deleted	-		0.93	0.8, 1.09	0.38
Apple	*1*	0.88	0.7, 1.1	0.26	deleted	-		0.95	0.77, 1.18	0.65
Peach	*1*	1.06	0.73, 1.52	0.77	deleted	-		1.19	0.7, 2.04	0.52
Nectarine	*1*	0.88	0.51, 1.54	0.67	deleted	-		0.49	0.11, 2.19	0.35
Grape	*25*	1.14	1.01, 1.27	0.03	1.11	1.0, 1.29	0.03	1.14	1.01, 1.29	0.03
Kiwi	*1*	0.85	0.51, 1.4	0.51	0.58	0.31, 1.29	0.12	0.64	0.29, 1.4	0.26
Orange	*1*	1.05	0.85, 1.29	0.66	deleted	-		1.06	0.85, 1.32	0.59
Persimmon	*1*	1.09	0.81, 1.49	0.56	deleted	-		1.07	0.76, 1.52	0.70
Tangerine	*1*	0.85	0.63, 1.15	0.29	deleted	-		0.84	0.6, 1.19	0.34
Pomegranate	*1*	1.04	0.79, 1.37	0.75	deleted	-		1.01	0.79, 1.3	0.93
Date	*4*	0.99	0.69, 1.44	0.97	deleted	-		0.97	0.63, 1.49	0.88
Plum	*4*	0.93	0.56, 1.54	0.78	deleted	-		0.82	0.36, 1.86	0.64

Variables*	Comparison group	Multiple Logistic Regression Model								
		GLIMMIX			Backward Selection			Full Model		
		OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Banana	*1*	1.32	1, 1.74	0.05	1.37	1.05,1.78	0.02	1.38	1.05, 1.83	0.02
Lemon	*1*	0.88	0.66, 1.17	0.38	deleted	-		0.87	0.62, 1.21	0.40
Sour Lemon	*1*	0.93	0.63, 1.37	0.71	deleted	-		0.90	0.54, 1.48	0.67
Cantaloupe Juice	*½ cup*	1.08	0.83, 1.41	0.57	deleted	-		1.07	0.79, 1.44	0.66
Packaged Fruit Juices	*4 sp*	1.11	0.94, 1.32	0.22	deleted	-		1.11	0.92, 1.33	0.26
Solid Oils	*4 sp*	1.13	0.67, 1.9	0.64	deleted	-		1.08	0.58, 2	0.81
Liquid Oil	*2 sp*	0.83	0.5, 1.37	0.46	0.58	0.28, 1.24	0.16	0.58	0.26, 1.3	0.19
Mayonnaise	*1 sp*	1.23	0.83, 1.82	0.29	1.36	0.89, 2.23	0.17	1.42	0.86, 2.36	0.18
Almonds	*4*	1.08	0.59, 1.97	0.81	deleted	-		1.06	0.3, 3.81	0.93
Walnut	*2*	1.04	0.69, 1.56	0.84	deleted	-		1.03	0.61, 1.74	0.92
Pistachios	*¼ cup*	1.02	0.72, 1.45	0.89	deleted	-		0.94	0.54, 1.63	0.82
Seeds	*½ cup*	1.28	0.88, 1.88	0.20	1.32	0.99, 1.77	0.053	1.33	0.99, 1.79	0.06
Sugar	*10*	0.84	0.47, 1.5	0.56	deleted	-		0.55	0.19, 1.62	0.28
Sugar Loaf	*5 sp*	0.80	0.43, 1.51	0.50	0.32	0.07, 1.33	0.12	0.27	0.05, 1.39	0.12
Honey	*2 sp*	1.02	0.69, 1.49	0.94	deleted	-		1.01	0.65, 1.56	0.98
Cola Drink	*1 cup*	1.18	0.84, 1.67	0.34	1.26	0.92, 1.73	0.15	1.34	0.94, 1.9	0.10
Tea	*1 cup*	0.99	0.94, 1.05	0.82	deleted	-		1.01	0.96, 1.06	0.69
Chips	*10 strip*	0.79	0.46, 1.35	0.39	0.52	0.22, 1.28	0.16	0.49	0.19, 1.28	0.15
Coffee	*½ cup*	0.97	0.82, 1.14	0.68	deleted			0.98	0.82, 1.17	0.85
Baked Mushrooms	*1 cup*	1.11	0.79, 1.55	0.56	deleted	-	-	1.18	0.79, 1.77	0.42
Salt	*1 gr*	1.02	0.97, 1.06	0.46	deleted	-	-	1.02	0.98, 1.07	0.35
Protein	*50 gr*	0.89	0.49, 1.62	0.69	-	-	-	-	-	-
Carbohydrates	*100 gr*	0.85	0.31, 2.33	0.76	-	-	-	-	-	-
Total Fat	*20 gr*	0.96	0.58, 1.59	0.87	-	-	-	-	-	-
Mon Saturate-Fatty Acids	*10 gr*	0.93	0.73, 1.18	0.53	-	-	-	-	-	-
Carotenoids	*2 gr*	1.00	1, 1	0.29	-	-	-	-	-	-
Calcium	*100 gr*	1.14	0.69, 1.89	0.6	-	-	-	-	-	-
Folates	*400 gr*	1.23	0.51, 2.96	0.65	-	-	-	-	-	-

Variables*	Comparison group	Multiple Logistic Regression Model								
		GLIMMIX			Backward Selection			Full Model		
		OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Magnesium	*350 gr*	1.20	0.47, 3.05	0.7	-	-	-	-	-	-
Zink	*10 gr*	0.87	0.68, 1.11	0.26	-	-	-	-	-	-
Total Fiber	*30 gr*	0.96	0.71, 1.29	0.77	-	-	-	-	-	-
Glucose	*20 gr*	0.50	0.2, 1.27	0.15	-	-	-	-	-	-
Fructose	*20 gr*	1.84	0.97, 3.51	0.06	-	-	-	-	-	-

†Semi-Bayes (Bayesian Multi-Level) included all 95 foods, all 12 nutrients, and nine covariates, we set $\tau_i = 0.35$ for each food.
§ Backward selection entered all 95 foods but no nutrients. 18 foods and seven covariates were retained and 77 foods deleted, ά-to-remove =0.2
§§ Full Model entered all 95 foods and nine covariates, but no nutrients.
*for the 95 foods, the comparisons are serving of each foods vs. none per day.

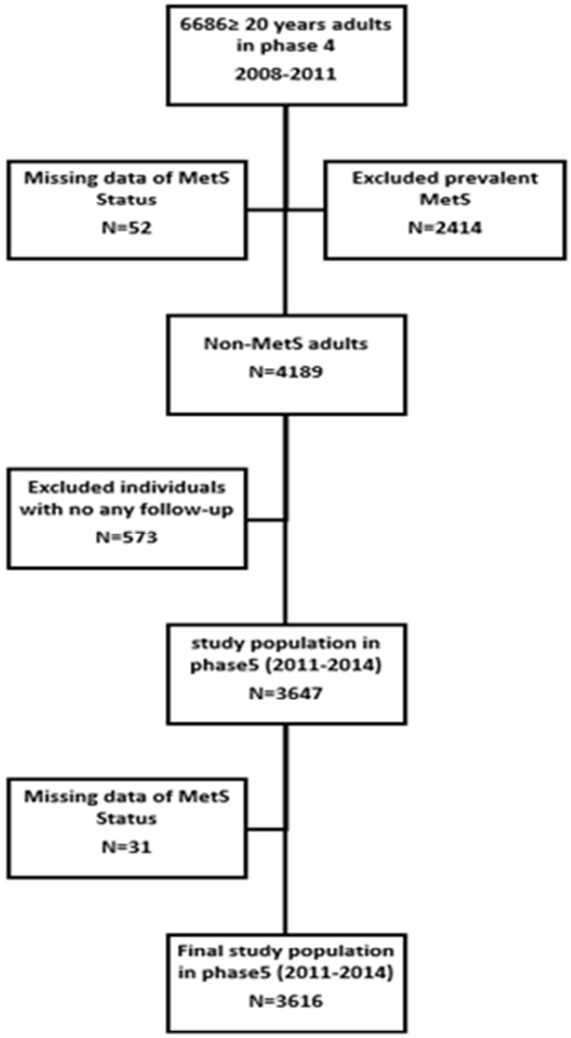

Figure 1. Follow up status of the TLGS participants after the baseline examination. MetS: Metabolic syndrome, TLGS: Tehran Lipid and Glucose Study.

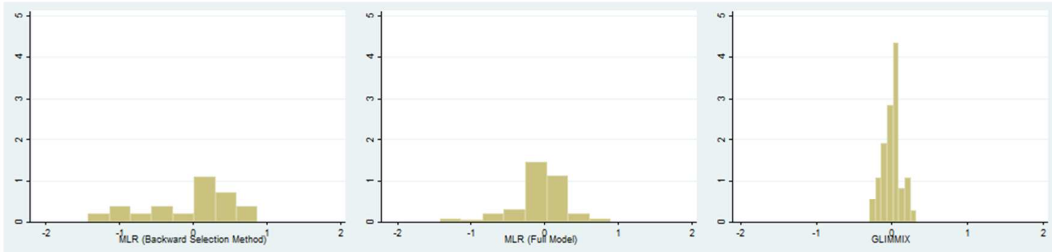

Figure 2. Histogram of maximum-Likelihood and penalized-likelihood coefficient estimates for the effects of dietary items on metabolic syndrome

BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-020642.R1
Article Type:	Research
Date Submitted by the Author:	20-Jul-2018
Complete List of Authors:	Cheraghi, Zahra; Tehran University of Medical Sciences; Hamadan University of Medical Sciences School of Public Health, Epidemiology Nedjat, Saharnaz; Department of epidemiology and biostatistics, School of public health, Knowledge utilization research center, Tehran University of medical sciences, Tehran, Iran. mansournia, Mohammad; , School of Public Health, Tehran University of Medical Sciences, Tehran, , Mirmiran, Parvin; Department of Clinical Nutrition and Dietetics, Faculty of Nutrition Sciences and Food Technology, National Nutrition and Food Technology Research Institute, Shahid Beheshti University of Medical Sciences, Tehran, Iran Moslehi, Nazanin; Nutrition and Endocrine Research Center, Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran. Mansournia, Nasrin; Aja University of Medical Sciences McCandless, Lawrence; Simon Fraser University, Department of Statstics and Actuarial Sciences
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Diabetes and endocrinology
Keywords:	Metabolic syndrome (MetS), ; Tehran Lipid and Glucose Study (TLGS), FFQ, generalized linear mixed model (GLIMMIX)

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Word count: 2985

Abstract

Objectives: Diet and nutrition may play an important role in the etiology of the metabolic syndrome. Most studies on the effects of food intake on metabolic syndrome (MetS) based on conventional analyses have investigated only a limited number of food items. This study was conducted with the goal of investigating the concurrent effect of numerous foods and related nutrients on the incidence of metabolic syndrome using Bayesian multilevel modeling and its comparison with conventional full logistic regression model and reduced logistic regression model through backward selection.

Design: Prospective cohort study.

Setting: This study was conducted on 3616 healthy adults aged ≥20 years who were free of MetS in the setting of Tehran Lipid and Glucose Study. We compared two statistical approaches. The first method used a Bayesian multilevel model fitted with GLIMMIX, whereas the second method used multiple logistic regression with two types of variable selection.
Participants: This study was conducted on 3616 healthy adults, aged ≥20 years.
Primary and secondary outcome measures: MetS was considered as the primary outcome.
Results: The Bayesian multilevel approach gave results that were more stable and realistic compared with the model that forced in all variables. For example, the confidence limits for the effects of four foods comparing the Bayesian multilevel and conventional model were: noodle soup [1.20 (0.67–2.14) vs. 1.91 (0.65–5.64)], beans [0.96 (0.5–1.85) vs. 0.55(0.03–11.41)], turnip [1.23 (0.68–2.23) vs. 2.48 (0.82–7.52)] and eggplant [1.01 (0.51–2.00) vs. 109396 (0.152×10^{-6}–768×10^{12})]. For most foods, the Bayesian multilevel approach gave more narrow confidence limits than either of the conventional approaches- and hence the best precision.
Conclusions: Our study shows the results of conventional analyses are biased when there are many highly correlated exposers. So despite the complexity of the Bayesian multilevel model, it is recommended for the analysis of multiple nutritional exposures that are highly correlated.
Keywords: Metabolic syndrome (MetS); Tehran Lipid and Glucose Study (TLGS); FFQ; generalized linear mixed model (GLIMMIX).

Strengths and limitations of this study:

- The design of the study was a prospective cohort study.
- In present study, the results were not biased due to the sparse data problem in Bayesian multilevel approach.
- All estimations in Bayesian multilevel approach were precise.
- Because of the well-known disadvantages of food frequency questionnaire (the possibility of measurement error and recall bias), some results may be distorted.

Introduction

Metabolic syndrome (MetS) is the clustering of at least three of the five following medical conditions: central/abdominal obesity, hypertension, elevated blood sugar, elevated triglyceride levels and reduced HDL levels [1]. MetS is associated with the risk of developing cardiovascular disease and diabetes. According to the World Health Organization (WHO], approximately 20–25 percent of the world's adult population is affected by MetS [1]. MetS is considered a multi-factorial disease in which nutritional exposures and diet are major contributing factors. According to nutritional studies, some foods have been recommended for preventing MetS. For example- legumes, whole grains, fruits, vegetables, nuts, fish, and low-fat dairy products, moderate consumption of alcohol. Also, other dietary patterns and approaches to stop hypertension, new Nordic, and vegetarian have been proposed [2].

Thus far, the effects of different foods on MetS have been investigated in many studies using conventional analyses such as multiple logistic regression [3-8].

In most of these studies which have used conventional models, only a limited number of food items have been investigated. This ignores the information we have about the effects of food through their nutrient contents. On the other hand, a conventional model that includes only nutrients erroneously assumes that there are no unmeasured nutrients or interactions among modeled nutrients and all food effects are transmitted through the measured nutrients [9, 10]. The simultaneous effects of numerous food items and related nutrients cannot be studied with conventional models due to the high collinearity. Another limitation is that the estimates from conventional models including all food items or all nutrients may suffer from sparse data bias [11-13].

Bayesian multilevel models can be used to deal with the aforementioned problems, providing the improvement in the precision and accuracy of estimates of effect [14]. Therefore, our objective was to examine the simultaneous effects of different food items and related nutrients on the incidence of MetS in healthy adults, using Bayesian multilevel models and their comparison with conventional full logistic regression model and reduced logistic regression model through backward selection.

Materials and Methods: This prospective study is part of the Tehran Lipid and Glucose Study (TLGS) [15]. The TLGS began in 1998 and was conducted on 15005 persons aged 3 to 63 years old from Tehran's District 13. We used the data collected in the fourth (2008–2011) and fifth (2011-–2014) follow-up examinations. Data related to dietary intake and other covariates were collected from the fourth phase, and new MetS cases were identified from the fifth phase, which was considered as the follow-up phase (Figure 1).

Target population: We selected 3616 adults aged ≥20 years who were not affected by MetS at the fourth follow-up examination (2008) and who had dietary information (Flowchart 1). The new MetS cases were 590 persons. All invited participants to the TLGS signed the informed written consent.

Inclusion criteria: Those who were eligible for the study included adults aged ≥20 years who had been followed up from the fourth to the fifth phase, and who had the following criteria: no history of chronic diseases (diabetes, stroke, thyroid problems and cancer); not following any specific dietary regime (such as a weight loss diet and the intake of fewer than 800 kcal or greater than 4000 kcal per day); and not being affected by MetS.

Measurement of outcome: MetS was defined according to the recent consensus guidelines [16] as having at least three of the following criteria: 1) abdominal obesity (waist circumference > 90 cm in both genders, *according to the third National survey in Iran* [17]; 2) lowered serum HDL levels (lower than 40 mg/dL in men and 50 mg/dL in women or the consumption of HDL–elevating drugs); 3) hypertension (a systolic BP≥130 mmHg or a diastolic BP≥85 mmHg or the consumption of antihypertensive drugs); 4) hyperglycemia (a fasting blood glucose (FBS) ≥100 mg/dL or the consumption of hypoglycemic drugs); and 5) hypertriglyceridemia (a serum triglyceride level ≥150 mg/dL or the consumption of triglyceride-lowering drugs).

Measurement of exposure: Nutritional data on the participants' dietary intake was collected using a semi-quantitative food frequency questionnaire (FFQ), which consists of 147 food items. Several nutritionists who had been trained in the field completed the questionnaires through face-to-face interviews. During the interview, the average size of each of the FFQ food items (which is equal to one food serving) was described to each participant, and then s/he was asked about the number of times each item was taken in the previous year. The validity and reliability of the FFQ has been already assessed through several studies in Iran and was found to be acceptable [18, 19] The consumption frequency of each food item in the previous year was assessed in the form of days, weeks, months and/or year, and then, using home scale guides, the amount consumed of each item was transformed into grams per day. The amount of intake of energy and nutrients was determined using the food composition table (see Table 2).

Other measured variables:

Other measured covariates included: weight, height, age, gender, marital status, history of hospitalization during previous three months, history of cancer, education (primary, intermediate, high school and high school graduate, academic education) and tobacco use (never smoked, previously smoked, currently smoking). Data were collected using a general information questionnaire interview administered by a nutritionist. Finally, we used the STROBE checklist for ensuring that all points are included in our paper.

Data analysis:

We estimated the effects of food items and nutrients on MetS using Bayesian multilevel and conventional analyses. The GLIMMIX software was used for the Bayesian multilevel analysis. Logistic regression (LR) with two types of variable selection (stepwise-backward selection or, alternatively, including all variables in the model) was applied in the conventional analysis approach.

In the Bayesian multilevel approach, we investigated the concurrent effects on MetS of 95 food items (listed in Table 2) and 12 nutrients (carbohydrates, protein, total fat, monounsaturated fatty acids, carotenoids, calcium, folate, magnesium, zinc, fiber, glucose, and fructose), adjusted for nine covariates (age, gender, cancer history, hospitalization status, educational status, body mass index, marital status, smoking history, and calories).

In the first conventional analysis (full model), 95 food items and nine covariates were forced into the model. Because of the high correlation between food items and nutrients resulting in the non-convergence of maximum likelihood estimates, the effects of nutrients were not investigated in the conventional analysis.

In the conventional analysis using stepwise backward selection, the alpha level for selection of food items was set at 0.2 and all nine confounders were forced into the model. Seventy-seven food items were removed at this stage, leaving 18 foods.

In all three models, the following six food items were removed from the models due to high collinearity between variables (Pearson correlation $\geq$0.4), retaining the food with a statistically stronger effect (specified in parentheses) in the final analysis: jam (sugar), plum (peach), lemon juice (lemon), apple juice (apple), orange juice (orange), and cooked vegetables (cooked carrots). Moreover, in all the models, 46 food items (data available upon request) were excluded from our analyses because it seemed unlikely that they would have considerable dietary effects on MetS. Thus 95 [147–(6+46)] food items were retained in the analysis.

To interpret the effects of foods on MetS more easily, each food item variable was transformed from 'grams' to specified servings using valid references based on daily servings [20].

Data analysis was done with Stata 11 (StataCorp, College Station, TX, USA) for the conventional analysis and SAS 9.2 for the Bayesian multilevel approach. The parameters of the LR and Bayesian multilevel models were estimated using maximum likelihood and shrinkage (penalized likelihood) methods, respectively. To compare the precision of estimates, we calculated the difference in confidence limits for odds ratios of foods in the logarithm scale (log upper odds ratio minus log lower odds ratio).

Structure of the Bayesian multilevel model

We can write the first stage model as: $\text{logit}(p \mid X, W) = \alpha + X\beta + W\gamma$

(1)

In this model, p is risk of MetS, $\boldsymbol{X}$ is the matrix of food items information, $\boldsymbol{W}$ is the matrix of other potential confounders, and **β** (β1, . . ., β95) is the vector of logistic regression coefficients corresponding to the 95 foods items. The first stage model is also the LR for the conventional analysis.

Second stage (2): $\boldsymbol{\beta}_j = \pi_1 z_{1j} + \pi_2 z_{2j} + \pi_p z_{pj} + \delta_j = \mathbf{z}_j \boldsymbol{\pi} + \boldsymbol{\delta}_j$

$$z_j = (z_{1j}, z_{2j}, \dots z_p) \quad (2)$$

$$\boldsymbol{\delta}_j \sim MVN\,(0, \tau_j)$$

Where $\boldsymbol{\pi}$ is the vector of coefficients of second-stage covariates for nutrients that may contribute to dietary effects on MetS. These second-stage covariates ($\boldsymbol{Z}$) include nutrients carbohydrates, protein, total fat, monounsaturated fatty acids, carotenoids, calcium, folate, magnesium, zinc, fiber, glucose, and fructose. The quantity δ_j is the residual effect of food item j, which is assumed to be an independent normal random variable with zero mean and standard deviation τ_j. Following Witte and Greenland [14], we specified a fixed value of tau to improve estimation convergence. Based on a similar study [14, 21], we set the standard deviation τ_j equal to 0.35 for all food items. This corresponds to our having 95% certainty that the odds ratio for the residual effects of foods (per serving of each food) lies between 0.5 and 2.0. The second stage can be interpreted as the prior distribution for the beta coefficients in the Bayesian multilevel method. The second-stage model shrinks the ordinary estimates toward each other when they have similar levels of nutrients.

Models 1 and 2 can be combined into a 'mixed-effects' model

$$logit\ (p|\boldsymbol{X},\ \boldsymbol{Z},\boldsymbol{W}) = (\alpha + \boldsymbol{X}(\boldsymbol{Z\pi} + \boldsymbol{\delta}) + \boldsymbol{W\gamma}) = \alpha + \boldsymbol{XZ\pi} + \mathbf{X}\boldsymbol{\delta} + \boldsymbol{W\gamma} \quad (3)$$

In this model, $\boldsymbol{\pi}$ and $\boldsymbol{\gamma}$ are treated as vectors of fixed coefficients, and δ is treated as a vector of random coefficients with mean zero and variance=0.1225. Hence one interpretation is that the multi-level model includes XZ interactions, which allow the effects of X on MetS to be similar when there is a similar nutrient level in the food items.

For estimating the fixed and random effects in the Bayesian multilevel model, the Mixed-Model Equations Solution Matrix (MMEQSOl) from SAS GLIMMIX output was used. MMEQSOl contains fixed $\hat{\pi}$, random $\hat{\delta}$, and covariate $\hat{\gamma}$ estimates and their respective estimated covariance matrices. In our study, the MMEQSOl was a 117*117 (95 foods+12 nutrients+ 9 covarites+1 intercept) matrix (Appendix 1).

Patient and public involvement: No patients were involved in the development and design of this prospective study.

Results

The mean (standard deviation **(**SD) age of participants and median follow-up time were 40.6 (12.6) years and 24.6 months, respectively. The total incidence rate of MetS was 82.2 (95% CI: 75.8–89.1) per 10000 person-years. The incidence rate of MetS was higher in males than in females (125.6 vs. 65.3 per 10000 person-years, p<0.001). In both genders, those affected by MetS were older (p<0.001). Also, the percentages of married individuals and those who had experienced a heart attack were higher among those with MetS than in the non-MetS people (p<0.001) (Table 1).

Conventional analysis

The adjusted odds ratios (95% CI) between food intakes and other covariates on MetS using logistic regression (LR) stepwise backward selection and the full model-are reported in Table 2. The conventional analysis is described in detail elsewhere [22].

Full model (LR with all food variables in the model)

Based on this model, two food items were associated with MetS: banana (OR=1.38, 95%CI: 1.05–1.83), and grapes (OR=1.14, 95%CI: 1.01–1.29). Two other food items were weakly associated with MetS as well: beef (OR=1.71, 95%CI: 0.95–3.08), and chicken (OR=1.24, 95%CI: 0.99–1.56). On the other hand, there was weak evidence of an inverse association of lamb meat (OR=0.44, 95%CI: 0.17–1.12) with MetS.

LR via Backward Selection Method

As mentioned in the methods section, only 18 foods remained in the final model. Based on this reduced model, grapes (OR: 1.11, 95%CI: –1.01–1.29, p=0.03) and banana (OR=1.37, 95%CI: 1.05–1.78, p=0.02) were associated with MetS. Also, there was some evidence that rice (OR=1.11, 95%CI: 0.99–1.2, p=0.06), turnip (OR=2.41, 95%CI: 0.77–6.69, p=0.09), and seeds (OR=1.32, 95%CI: 0.99–1.77, p=0.053) were positively associated with MetS. On the other hand, lamb meat seemed to be inversely associated with MetS (OR: 0.40, 95%CI: 0.16–0.99, p=0.05).

Multi-level Bayesian Analysis via the GLIMMIX

Based on this model, grapes (OR=1.14, 95%CI: 1.01–1.27, p=0.03) and banana (OR=1.32, 95%CI: 1.01–1.74, p=0.05) were positively associated with MetS. There was also evidence that fructose was positively associated with the risk for MetS (OR=1.84, 95%CI: 0.97–3.51, p=0.06) (Table 2).

Upon comparing the three models, 15 (83.3%) of the odds ratio estimates were the smallest (toward the null) in the Bayesian multilevel model, which is unsurprising given that the mean of the residual effects of foods (δ_j) was pre-specified as zero, so the odds ratio estimates underwent shrinkage toward the null value. In the remaining three foods (16.6%), the odds ratio estimates were very similar between models.

Discussion

Although diet may play a role in the etiology of MetS, most previous studies have only looked at a limited number of food items because of limitations of conventional modeling approaches [8-9]. On the other hand, multi-level models and shrinkage estimators are known to give lower prediction error and improve the precision and accuracy of estimates of effect [14]. We used Bayesian multilevel models to study the simultaneous effects of different food items and related nutrients on the incidence of MetS and compared it to conventional models. We used three models (backward selection and full conventional model, and Bayesian multilevel model) from two analytical approaches to estimate the adjusted effects of food items and nutrients related to MetS among adults in the Tehran and Lipid Glucose Study.

Banana and grapes were the only items that were associated with MetS in all three models. However, upon stratifying by diabetes status, the effects were weaker in the non-diabetes group. Furthermore, because of the small sample size of the diabetic group (37 new cases of MetS in the 328-populated diabetics group: 0.11 case per event), model fitting in this group did not converge.

The histogram of regression coefficients of dietary items indicates the penalized likelihood estimates (from GLIMMIX) are much less dispersed than the maximum likelihood estimates in conventional analyses (Figure 2). Also, GLIMMIX has a better goodness of fit than the conventional models: The Deviance Information Criterions (DICs) for backward selection method, full model and GLIMMIX were 29057.6, 27679.9 and 18122.1 respectively.

The largest odds ratio estimates were observed in the full-model so that the odds ratio estimates in GLIMMIX were more similar to the backward rather than to the full model. For 10 (55.5%) of 18 common odds ratios, the

GLIMMIX had the narrowest confidence limits and the highest precision. For seven (38.8%) of odds ratios, the backward model had the best precision. In one (5%), there was similar precision. The full model had the best precision in only one estimate. Although in the backward method only 18 variables remained in the final model, GLIMMIX outperformed backward method in terms of precision of the odds ratio estimates.

In the 77 (95–18) remaining food items that were common in the GLIMMIX and full model, Bayesian multilevel modeling exhibited better precision (60 (78%) vs. 15 (0.20%)). In two (2%) of odds ratios, both models exhibited a similar status.

In the Bayesian multilevel model, the confidence limits for four odds ratios (that were extreme) were stable and realistic as follows: noodle soup ([0.67–2.14] vs. [0.65–5.64]), beans ([0.5–1.85] vs. [0.03–11.41]), turnip ([0.68–2.23] vs. [0.82–7.52]). In the conventional analysis (LR-full model), the estimation for eggplant was strongly affected by the sparse data bias [11, 12], (OR=109396, 95%CI=0.152×10^768×1012), but this implausible and imprecise estimation was balanced in the Bayesian multilevel model (OR=1.01, 95%CI=0.51–2.00). This balancing of extreme estimates has been shown in earlier studies [14, 21].

The most significant limitation of the stepwise backward selection method was the deletion of some variables from the model, which assumes with full certainty they have no effect- since the final selected model does not take into account the uncertainty in the selection procedure. As mentioned in the backward method, 77 variables were removed from the final model; such variable selection leads to downward bias in the p-values and standard errors for the reaming variables in the model [23].

Various studies [24, 25] have shown the protective effects of vegetables and fruits on MetS. These substances exert their protective effects through beneficial combinations such as antioxidants, fiber, potassium and other herbal chemicals, reducing the concentration of CRP (C-Reactive Protein) [26]. But because of the low power of the study (according to a rule of thumb in statistics), logistic models require a minimum of 10 events per predictor variable. As we should estimate the effect of 117 variables (95 food

intakes plus nine confounders) this means we require 1040 cases while in our study only 590 new cases of MetS developed), we did not detect any associations for such fruits and vegetables, like kiwifruit, watermelon, apple, cherry, plum, tangerine, dates, nectarine, lemon, tomato, celery, raw onion, cooked cabbage, lettuce and potato.

Moreover, we detected a weak association between fructose and MetS. Some studies [27-29] have shown that the consumption of foods and beverages that are high in fructose facilitate dyslipidemia (increased triglycerides and LDL, and decreased HDL). As previously mentioned [1], hyperlipidemia is considered as one of the components of metabolic syndrome, hence this finding is consistent with earlier studies.

Esmailzadeh, Maras and Ruidavets [30-32] have shown the protective effect of whole grains on the incidence of MetS, though we did not detect such an association. However, that study assessed only a limited number of foods and the results may be subject to bias.

The most important limitation of this study was the well-known disadvantages of using an FFQ to assess food intake. Several studies have shown that the FFQ has limitations in determining dietary patterns- since it encompasses a long list of foods consumed during the past year. Also, the FFQ underestimates the consumption of proteins and carbohydrates, so the possibility of measurement error and recall bias that can distort the results exists [33-35]. There was also an issue with limited sample size (dimensionality and non-convergence problem). According to a rule of thumb in statistics [36], logistic models require a minimum of 10 cases per parameter. As we estimated the effect of 104 variables (95 food intakes plus nine confounders), we require 1050 cases while in our study only 590 new cases of MetS developed. However, this problem is partly resolved in the Bayesian multilevel approach. Finally, there are other sources of bias including measurement error in variables, model mis-specification, unmeasured confounding, and ignorance of time-varying confounding (37).
In conclusion, Bayesian multilevel models present more precise and sensible estimates of association than the conventional models, and they can reduce sparse data bias. Despite the complexity of the semi-Bayes model, it is recommended for the analysis of multiple, correlated and multi-level nutritional exposures.

Ethical approval: Shahid Beheshti University of Medical Sciences (SUMS)/ Research Ethics Board.

Acknowledgments: We thank John Witte for his helpful comments on an earlier draft of this paper. We extend our gratitude to the authorities of the 'Research Institute for Endocrine Sciences' at Shahid Beheshti University of Medical Sciences for sharing their valuable data with us. Moreover, we are grateful to all the participants for availing us their valuable time. The authors also have no conflicts of interest and have no involvement that might raise the question of bias in the results reported here.

Contributorship statement: (Z.Ch conducted research, Z.Ch and N.Mo provided essential reagents or provided essential materials, Z.Ch, S N, M.M and P.M analyzed data or performed statistical analysis. Ch, S N,

M.M, P.M and L.Mc wrote the paper, Ch, S N, M.M, P.M, N.Ma, N.Mo and L.Mc had primary responsibility for final content; Z.Ch had responsibility for all parts of the manuscript).

Competing interests: None declared.

Funding: This article has been extracted from the first author's Ph.D. thesis (code: 912-112-8002) and was supported by Tehran University of Medical Sciences (TUMS).

Data sharing statement: Data available on request.

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Table 1. Comparison of baseline characteristics of subjects who did and did not develop incident MetS after three years of follow-up

Variables	Men			Women			All		
	Non-MetS (N=1082)	MetS (N=291)	P-v*	Non-MetS (N=1944)	MetS (N=299)	P-v	Non-MetS (N=3026)	MetS (N=590)	P-v
Age (years)	41.60	43.77	0.01	38.87	47.06	<0.001	39.84	45.43	<0.001
BMI (kg/m^2)	26.31	30.67	<0.001	25.41	28.08	<0.001	25.98	29.39	<0.001
Marital status (%)			<0.001			<0.001			<0.001
Married	75.44	86.94		77.28	87.29		75.44	87.12	
Single/Divorced/Widowed	24.65	13.06		22.72	12.71		24.56	12.88	
HMI (%)	0.09	0.69	0.02	0.00	0.33	0.01	0.03	0.51	<0.001
FHDM (%)	6.76	4.48	0.15	11.23	8.03	0.24	9.63	6.28	0.02
Smoking (%)			0.89			0.69			0.13
Never	78.33	78.69		96.55	96.99		90.03	87.97	
Current/Past	21.67	21.31		3.45	3.01		9.97	12.03	
Education level (%)			0.77			<0.001			<0.001
Higher than diploma	41.77	42.61		42.03	22.41		41.94	32.37	
Diploma/below diploma	51.57	51.89		50.82	64.21		51.09	58.14	
Illiterate/Primary school	6.65	5.50		7.15	13.38		6.67	9.49	
Cancer history (%)	0.19	0.34	0.60	0.52	1.34	0.09	0.40	0.85	0.14
Hospitalization (%)	12.04	11.36	0.90	6.25	15.87	0.01	7.66	14.02	0.03

*: The p-value of *t*-test and Chi-squared test; FBS: fasting blood sugar; BMI: body mass index; DM: diabetes mellitus; HMI: history of myocardial infraction disease; FHDM: family history of diabetes mellitus.

Table 2: The effects of food items, nutrients and other covariates on MetS from conventional and Bayesian multilevel (Semi-Bayes) analyses

Variables*	**Comparison group**	**Multiple logistic Regression Model**								
		GLIMMIX			**Backward Selection**			**Full Model**		
		OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
Gender	*Female/male*	0.47	0.38, 0.59	**<0.01**	0.47	0.36, 0.58	**<0.01**	0.46	0.36, 0.58	**<0.01**
Age	*Per 5 years*	1.16	1.11, 1.21	**<0.01**	1.16	1.11, 1.22	**<0.01**	1.16	1.11, 1.22	**<0.01**
Energy	*Per kcal*	1.02	0.98, 1.03	0.85	0.99	1, 1.01	0.10	0.98	1, 1.01	0.53
Cancer History	*Yes vs. no*	2.02	0.59, 6.95	0.26	1.90	0.54, 6.68	0.32	2.00	0.54, 6.68	0.29
Hospitalization	*Yes vs. no*	1.85	0.93, 3.65	0.08	1.96	0.98, 3.90	0.05	1.85	0.98, 3.90	0.09
Smoking	*Yes vs. no*	1.23	0.86, 1.76	0.25	1.23	0.86, 1.77	0.25	1.27	0.86, 1.77	0.21
Body Mass Index	*(kg/m^2)*	1.19	1.17, 1.22	**<0.01**	1.19	1.16, 1.22	**<0.01**	1.19	1.16, 1.22	**<0.01**
Education	*Per one degree*	1.34	1.02, 1.76	**0.04**	1.12	0.99, 1.27	0.07	1.34	0.99, 1.27	**0.04**
Marriage	*married vs. single*	1.13	1.01, 1.28	**0.04**	1.34	1.2, 1.78	**0.04**	1.15	1.2, 1.78	**0.05**
Barbari *(Type of Bread)*	*1/4*	1.03	0.67, 1.58	0.89	deleted	-		1.01	0.36, 0.58	0.84
Sangak *(Type of Bread)*	*1/4*	1.00	0.79, 1.26	0.97	deleted	-		1.04	1.11, 1.22	0.71
Taftun *(Type of Bread)*	*1/2*	1.03	0.73, 1.45	0.88	deleted	-		0.97	0.99, 1	0.72
Baguette	*1/2*	0.98	0.79, 1.21	0.83	deleted	-		0.64	0.56, 7.21	0.40
Lavash *(Type of Bread)*	*1*	0.84	0.48, 1.48	0.55	deleted	-		1.07	0.91, 3.76	0.62
Cooked Rice	*1 cup*	1.05	0.83, 1.34	0.66	1.11	0.99, 1.24	0.057	1.10	0.87, 1.84	0.18
Pasta	*1 cup*	1.20	0.77, 1.87	0.43	deleted	-		1.43	1.17, 1.22	0.23
Potato	*1*	0.89	0.54, 1.46	0.65	deleted	-		0.76	0.35, 1.62	0.47
Fried Potato	*10 strip*	1.04	0.78, 1.39	0.79	deleted	-		1.07	0.77, 1.47	0.70
Noodle Soup	*¾ cup*	1.20	0.67, 2.14	0.54	deleted	-		1.91	0.65, 5.64	0.24
Noodle Ash *(Type of soup)*	*1 cup*	0.99	0.57, 1.73	0.98	deleted	-		0.93	0.36, 2.44	0.88
Cracker	*1*	0.94	0.73, 1.22	0.64	deleted	-		0.95	0.71, 1.27	0.73
Corn	*¼ cup*	1.03	0.76, 1.4	0.84	deleted	-		1.02	0.72, 1.45	0.89
Barley	*¼ cup*	1.13	0.74, 1.73	0.58	deleted	-		1.17	0.65, 2.08	0.60
Lentil	*½ cup*	1.10	0.76, 1.59	0.62	deleted	-		1.23	0.86, 1.75	0.26

Variables*	Comparison group	Multiple logistic Regression Model								
		GLIMMIX			Backward Selection			Full Model		
		OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Beans	*½ cup*	1.06	0.64, 1.75	0.83	deleted	-		1.03	0.45, 2.36	0.95
Pea	*½ cup*	1.25	0.77, 2.04	0.37	1.66	0.88, 3.09	0.11	1.55	0.71, 3.38	0.27
Bean	*2 cup*	0.96	0.5, 1.85	0.91	deleted	-		0.55	0.03, 1.41	0.70
Soya	*½ cup*	0.80	0.48, 1.3	0.36	deleted	-		0.67	0.3, 1.51	0.34
Cotyledon	*1 cup*	1.02	0.57, 1.83	0.96	deleted	-		0.97	0.29, 3.27	0.96
Lamb Meat	*2 oz*	0.77	0.45, 1.33	0.34	0.40	0.16, 0.99	0.05	0.44	0.17, 1.12	0.09
Beef	*2 oz*	1.39	0.88, 2.19	0.16	1.54	0.88, 2.71	0.13	1.71	0.95, 3.08	0.08
Ground beef	*2 oz*	0.88	0.53, 1.47	0.63	deleted	-		0.79	0.35, 1.76	0.56
Chicken	*3.5 oz*	1.24	0.87, 1.78	0.24	1.19	0.96, 1.48	0.10	1.24	0.99, 1.56	0.06
Fish	*3.5 oz*	1.02	0.77, 1.34	0.90	deleted	-		1.00	0.87, 1.14	0.97
Canned Fish	*3.5 oz*	0.98	0.53, 1.8	0.94	deleted	-		0.91	0.23, 3.53	0.89
Sausage	*100 gr*	0.88	0.46, 1.7	0.71	deleted	-		0.26	0.02, 3.15	0.29
Egg	*1*	1.00	1, 1	0.78	deleted	-		1.00	1, 1	0.79
Pizza	*100 gr*	0.96	0.62, 1.48	0.85	deleted	-		0.94	0.55, 1.62	0.83
Low-Fat Milk	*1 cup*	1.00	0.8, 1.26	0.99	deleted	-		1.04	0.84, 1.27	0.74
Whole-Fat Milk	*1 cup*	0.97	0.77, 1.21	0.77	deleted	-		1.00	0.81, 1.23	0.98
Chocolate Milk	*1 cup*	1.10	0.75, 1.63	0.62	deleted	-		1.22	0.77, 1.94	0.39
Yogurt	*½ cup*	1.08	0.84, 1.39	0.56	deleted	-		1.12	0.88, 1.43	0.34
Strain Yogurt	*1 cup*	0.93	0.76, 1.13	0.47	deleted	-		0.96	0.83, 1.11	0.58
Whole Fat Yogurt	*1 cup*	0.90	0.71, 1.14	0.37	deleted	-		0.91	0.73-1.12	0.37
Cheese	*1 oz*	1.06	0.9, 1.25	0.47	1.10	0.96, 1.27	0.15	1.09	0.93-1.28	0.26
Whole-Fat Cheese	*2 oz*	0.85	0.5, 1.43	0.53	deleted	-		0.63	0.26-1.52	0.31
Yogurt Drink	*1 cup*	1.08	0.77, 1.51	0.65	deleted	-		1.15	0.82, 1.61	0.43
Traditional Ice Cream	*1 cup*	1.04	0.64, 1.7	0.86	deleted	,		1.10	0.54-2.25	0.79
Butter	*1 cup*	0.92	0.6, 1.42	0.72	deleted	-		0.85	0.49-1.46	0.56
Shredded Lettuce	*1.5 cup*	0.84	0.56, 1.26	0.39	deleted			0.75	0.44-1.29	0.30
Tomato	*1*	0.99	0.8, 1.21	0.91	0.89	0.77, 1.2	0.12	0.89	0.75, 1.05	0.18
Cucumbers	*1*	1.05	0.91, 1.21	0.52	deleted	-		1.06	0.9, 1.24	0.48

Variables*	Comparison group	Multiple logistic Regression Model								
		GLIMMIX			Backward Selection			Full Model		
		OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Vegetables	*1.5 cup*	1.24	0.72, 2.11	0.44	deleted	-		1.62	0.67, 3.9	0.28
Eggplant	*3.5 oz*	1.01	0.51, 2	0.98	deleted	-		109396	0, 79*10^15	0.41
Cooked Celery	*1/3 cup*	0.95	0.52, 1.76	0.88	deleted	-		0.71	0.16, 3.11	0.65
Green Peas Cooked	*½ cup*	0.82	0.45, 1.47	0.50	0.41	0.12, 1.44	0.14	0.38	0.09, 1.58	0.18
Green Beans Cooked	*¼ cup*	0.98	0.64, 1.5	0.93	deleted	-		1.11	0.61, 2.02	0.73
Raw Carrots	*1*	1.01	0.67, 1.53	0.95	deleted	-		0.87	0.56, 1.35	0.54
Cooked Carrots	*½ cup*	1.04	0.61, 1.78	0.88	deleted	-		0.81	0.39, 1.68	0.57
Raw Onion	*1/3 cup*	0.94	0.69, 1.28	0.70	deleted	-		0.88	0.61, 1.28	0.50
Fried Onions	*½ cup*	1.06	0.73, 1.53	0.78	deleted	-		1.03	0.65, 1.62	0.91
Cabbage	*½ cup*	0.91	0.72, 1.17	0.48	deleted	-		0.90	0.68, 1.19	0.47
Green Pepper	*½ cup*	1.06	0.68, 1.66	0.80	deleted	-		1.05	0.57, 1.93	0.87
Cooked Spinach	*½ cup*	1.09	0.62, 1.91	0.76	deleted	-		0.90	0.36, 2.25	0.82
Turnip	*2/3 cup*	1.23	0.68, 2.23	0.49	2.41	0.77, 6.69	0.09	2.48	0.82, 7.52	0.11
Ketchup	*1 sp*	0.97	0.64, 1.46	0.88	deleted	-		0.91	0.54, 1.53	0.73
Pickle	*2 sp*	1.04	0.88, 1.23	0.66	deleted	-		1.05	0.91, 1.22	0.51
Cantaloupe	*1*	1.10	0.81, 1.51	0.54	deleted	-		1.07	0.75, 1.54	0.70
Melon	*1*	1.00	0.69, 1.45	0.98	deleted	-		1.01	0.63, 1.63	0.96
Watermelon	*¾ cup*	0.98	0.74, 1.3	0.91	deleted	-		0.90	0.71, 1.14	0.38
Pear	*1*	1.04	0.72, 1.51	0.81	deleted	-		1.05	0.66, 1.67	0.84
Cherry	*15*	0.95	0.83, 1.09	0.44	deleted	-		0.93	0.8, 1.09	0.38
Apple	*1*	0.88	0.7, 1.1	0.26	deleted	-		0.95	0.77, 1.18	0.65
Peach	*1*	1.06	0.73, 1.52	0.77	deleted	-		1.19	0.7, 2.04	0.52
Nectarine	*1*	0.88	0.51, 1.54	0.67	deleted	-		0.49	0.11, 2.19	0.35
Grape	*25*	1.14	1.01, 1.27	0.03	1.11	1.0, 1.29	0.03	1.14	1.01, 1.29	0.03
Kiwi	*1*	0.85	0.51, 1.4	0.51	0.58	0.31, 1.29	0.12	0.64	0.29, 1.4	0.26
Orange	*1*	1.05	0.85, 1.29	0.66	deleted	-		1.06	0.85, 1.32	0.59
Persimmon	*1*	1.09	0.81, 1.49	0.56	deleted	-		1.07	0.76, 1.52	0.70

Variables*	Comparison group	Multiple logistic Regression Model								
		GLIMMIX			Backward Selection			Full Model		
		OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Tangerine	*1*	0.85	0.63, 1.15	0.29	deleted	-		0.84	0.6, 1.19	0.34
Pomegranate	*1*	1.04	0.79, 1.37	0.75	deleted	-		1.01	0.79, 1.3	0.93
Date	*4*	0.99	0.69, 1.44	0.97	deleted	-		0.97	0.63, 1.49	0.88
Plum	*4*	0.93	0.56, 1.54	0.78	deleted	-		0.82	0.36, 1.86	0.64
Banana	*1*	1.32	1, 1.74	0.05	1.37	1.05,1.78	0.02	1.38	1.05, 1.83	0.02
Lemon	*1*	0.88	0.66, 1.17	0.38	deleted	-		0.87	0.62, 1.21	0.40
Sour Lemon	*1*	0.93	0.63, 1.37	0.71	deleted	-		0.90	0.54, 1.48	0.67
Cantaloupe Juice	*½ cup*	1.08	0.83, 1.41	0.57	deleted	-		1.07	0.79, 1.44	0.66
Packaged Fruit Juices	*4 sp*	1.11	0.94, 1.32	0.22	deleted	-		1.11	0.92, 1.33	0.26
Solid Oils	*4 sp*	1.13	0.67, 1.9	0.64	deleted	-		1.08	0.58, 2	0.81
Liquid Oil	*2 sp*	0.83	0.5, 1.37	0.46	0.58	0.28, 1.24	0.16	0.58	0.26, 1.3	0.19
Mayonnaise	*1 sp*	1.23	0.83, 1.82	0.29	1.36	0.89, 2.23	0.17	1.42	0.86, 2.36	0.18
Almonds	*4*	1.08	0.59, 1.97	0.81	deleted	-		1.06	0.3, 3.81	0.93
Walnut	*2*	1.04	0.69, 1.56	0.84	deleted	-		1.03	0.61, 1.74	0.92
Pistachios	*¼ cup*	1.02	0.72, 1.45	0.89	deleted	-		0.94	0.54, 1.63	0.82
Seeds	*½ cup*	1.28	0.88, 1.88	0.20	1.32	0.99, 1.77	0.053	1.33	0.99, 1.79	0.06
Sugar	*10*	0.84	0.47, 1.5	0.56	deleted	-		0.55	0.19, 1.62	0.28
Sugar Loaf	*5 sp*	0.80	0.43, 1.51	0.50	0.32	0.07, 1.33	0.12	0.27	0.05, 1.39	0.12
Honey	*2 sp*	1.02	0.69, 1.49	0.94	deleted	-		1.01	0.65, 1.56	0.98
Cola Drink	*1 cup*	1.18	0.84, 1.67	0.34	1.26	0.92, 1.73	0.15	1.34	0.94, 1.9	0.10
Tea	*1 cup*	0.99	0.94, 1.05	0.82	deleted	-		1.01	0.96, 1.06	0.69
Chips	*10 strip*	0.79	0.46, 1.35	0.39	0.52	0.22, 1.28	0.16	0.49	0.19, 1.28	0.15
Coffee	*½ cup*	0.97	0.82, 1.14	0.68	deleted			0.98	0.82, 1.17	0.85
Baked Mushrooms	*1 cup*	1.11	0.79, 1.55	0.56	deleted	-	-	1.18	0.79, 1.77	0.42
Salt	*1 gr*	1.02	0.97, 1.06	0.46	deleted	-	-	1.02	0.98, 1.07	0.35
Protein	*50 gr*	0.89	0.49, 1.62	0.69	-	-	-	-	-	-
Carbohydrates	*100 gr*	0.85	0.31, 2.33	0.76	-	-	-	-	-	-
Total Fat	*20 gr*	0.96	0.58, 1.59	0.87	-	-	-	-	-	-

Variables[*]	Comparison group	Multiple logistic Regression Model								
		GLIMMIX			Backward Selection			Full Model		
		OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Mon Saturate-Fatty Acids	*10 gr*	0.93	0.73, 1.18	0.53	-	-	-	-	-	-
Carotenoids	*2 gr*	1.00	1, 1	0.29	-	-	-	-	-	-
Calcium	*100 gr*	1.14	0.69, 1.89	0.6	-	-	-	-	-	-
Folates	*400 gr*	1.23	0.51, 2.96	0.65	-	-	-	-	-	-
Magnesium	*350 gr*	1.20	0.47, 3.05	0.7	-	-	-	-	-	-
Zink	*10 gr*	0.87	0.68, 1.11	0.26	-	-	-	-	-	-
Total Fiber	*30 gr*	0.96	0.71, 1.29	0.77	-	-	-	-	-	-
Glucose	*20 gr*	0.50	0.2, 1.27	0.15	-	-	-	-	-	-
Fructose	*20 gr*	1.84	0.97, 3.51	0.06	-	-	-	-	-	-

†Semi-Bayes (Bayesian Multi-Level) included all 95 foods, all 12 nutrients, and nine covariates, we set $\tau_i = 0.35$ for each food.
§ Backward selection entered all 95 foods but no nutrients. 18 foods and seven covariates were retained and 77 foods deleted, ά-to-remove =0.2
§§ Full Model entered all 95 foods and nine covariates, but no nutrients.
*for the 95 foods, the comparisons are serving of each foods vs. none per day.

Figure 1: Follow up the status of the TLGS participants after the baseline examination. MetS: Metabolic Syndrome, TLGS: Tehran and Lipid and Glucose study
Figure 2: Histogram of maximum-Likelihood and penalized-likelihood coefficients for the effects of dietary items on metabolic syndrome

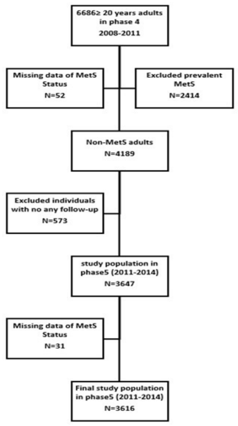

Figure 1: Follow up the status of the TLGS participants after the baseline examination. MetS: Metabolic Syndrome, TLGS: Tehran and Lipid and Glucose study

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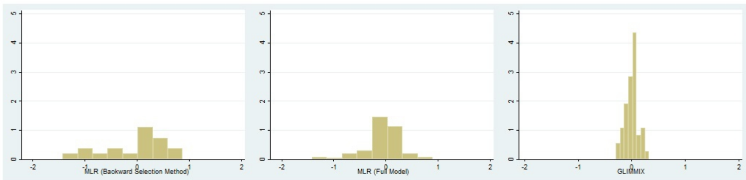

Figure 2: Histogram of maximum-Likelihood and penalized-likelihood coefficients for the effects of dietary items on metabolic syndrome.

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BMJ Open

Effects of Food Items and Related Nutrients on Metabolic Syndrome Using Bayesian Multilevel Modeling Using the Tehran Lipid and Glucose Study (TLGS): A Cohort Study.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-020642.R2
Article Type:	Research
Date Submitted by the Author:	15-Nov-2018
Complete List of Authors:	Cheraghi, Zahra; Tehran University of Medical Sciences; Hamadan University of Medical Sciences School of Public Health, Epidemiology Nedjat, Saharnaz; Department of epidemiology and biostatistics, School of public health, Knowledge utilization research center, Tehran University of medical sciences, Tehran, Iran. Mirmiran, Parvin; Department of Clinical Nutrition and Dietetics, Faculty of Nutrition Sciences and Food Technology, National Nutrition and Food Technology Research Institute, Shahid Beheshti University of Medical Sciences, Tehran, Iran Moslehi, Nazanin; Nutrition and Endocrine Research Center, Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran. Mansournia, Nasrin; Aja University of Medical Sciences Etminan, Mahyar; University of British Columbia mansournia, Mohammad; , School of Public Health, Tehran University of Medical Sciences, Tehran, , McCandless, Lawrence; Simon Fraser University, Department of Statstics and Actuarial Sciences
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Diabetes and endocrinology
Keywords:	Metabolic syndrome (MetS), ; Tehran Lipid and Glucose Study (TLGS), FFQ, generalized linear mixed model (GLIMMIX)

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Title: Effects of Food Items and Related Nutrients on Metabolic Syndrome Using Bayesian Multilevel Modeling Using the Tehran Lipid and Glucose Study (TLGS): A Cohort Study

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Word count: 3279

Keywords: Metabolic syndrome (MetS); Tehran Lipid and Glucose Study (TLGS); FFQ; generalized linear mixed model (GLIMMIX). Bayesian statistics

Abstract

Objectives: Diet and nutrition might play an important role in the etiology of metabolic syndrome (MetS). Most studies that examine the effects of food intake on MetS have used conventional statistical analyses which usually investigate only a limited number of food items and are subject to sparse data bias. This study was undertaken with the goal of investigating the concurrent effect of numerous food items and related nutrients on the incidence of MetS using Bayesian multilevel modeling which can control for sparse data bias.

Design: Prospective cohort study

Setting: This prospective study was a sub-cohort of the Tehran Lipid and Glucose Study (TLGS). We analyzed dietary intake as well as pertinent covariates for cohort members in the fourth (2008–2011) and fifth (2011–2014) follow-up examinations. We fitted Bayesian multilevel model and compared the results with two logistic regression models: 1) full model which included all variables and 2) reduced model through backward selection of dietary variables.

Participants: 3616 healthy Iranian adults, aged ≥20 years.

Primary and secondary outcome measures: Incident cases of metabolic syndrome

Results: Bayesian multilevel approach produced results that were more precise and biologically plausible compared with conventional logistic regression models. The odds ratio (OR) and 95% confidence limits for the effects of the four foods comparing the Bayesian multilevel with the full conventional model were as follows: 1) noodle soup [1.20 (0.67–2.14) vs. 1.91 (0.65–5.64)], 2) beans [0.96 (0.5–1.85) vs. 0.55(0.03–11.41)],3) turnip [1.23 (0.68–2.23) vs. 2.48 (0.82–7.52)] and 4) eggplant [1.01 (0.51–2.00) vs. 109396 (0.152×10^{-6}–768×10^{12})]. For most food items, the Bayesian multilevel analysis gave narrower confidence limits than both logistic regression models and hence provided the highest precision.

Conclusions: This study demonstrates that conventional regression methods do not perform well and might even be biased when assessing highly correlated exposures such as food items in dietary epidemiological studies. Despite the complexity of the Bayesian multilevel models and their inherent assumptions, this approach

performs superior to conventional statistical models in studies that examine multiple nutritional exposures that are highly correlated.

Strengths and limitations of this study:

- A prospective cohort study using three statistical models.
- A Bayesian multilevel model was used to control for sparse data bias present in many nutritional studies that use non-Bayesian analyses.
- Generation of precise effect estimates for all comparisons.
- Food frequency questionnaires used in this study may be subject to measurement bias.

INTRODUCTION

Metabolic syndrome (MetS) is the clustering of at least three of the five following medical conditions: central/abdominal obesity, hypertension, elevated blood sugar, elevated triglyceride levels and reduced HDL levels [1]. MetS is associated with the risk of developing cardiovascular disease and diabetes [1]. According to the World Health Organization (WHO), approximately 20–25 percent of the world's adult population is affected by MetS [1]. MetS is considered a multi-factorial disease in which nutritional exposures and diet are major contributing factors. According to nutritional studies, a number of foods have been recommended for preventing MetS. These foods include legumes, whole grains, fruits, vegetables, nuts, fish, low-fat dairy products and moderate consumption of alcohol. Moreover, other dietary patterns and approaches to slow the incidence of hypertension, including a vegetarian diet have been proposed [2]. Thus far, the effects of different foods on MetS have only been investigated in many epidemiological studies using conventional statistical analyses such as multiple logistic regression [3-8]. In most of these studies, only a limited number of food items have been investigated. This approach excludes potential benefits of foods that might exist through their nutrient contents. Conversely, a conventional model that includes only measured nutrients erroneously assumes that there are no unmeasured indirect nutrient effects or interactions among the modeled nutrients under the assumption that all food effects are transmitted through the measured nutrients [9, 10]. Simultaneous effects of numerous food items and related nutrients cannot be studied with conventional statistical models due the potential for collinearity (strong correlation between two nutrient variables that may lead to loss of precision of effect sizes). Another limitation is that inclusion of all food items in conventional statistical model is that the estimates from these models may suffer from sparse data bias [11-13]. In such circumstances, Bayesian multilevel models can be used to deal with the aforementioned problems by providing substantial improvement in the precision of effect sizes [14]. Therefore, our study objective was to examine the simultaneous effects of different food items and related nutrients on the incidence of MetS in healthy adults, using 1) a Bayesian multilevel model, 2) a conventional full logistic regression model and 3) a reduced logistic regression model through backward selection.

MATERIALS AND METHODS

This prospective study is part of the Tehran Lipid and Glucose Study (TLGS) [15]. The TLGS began in 1998 and was conducted on 15,005 persons aged 3 to 63 years from Tehran's District 13. We used the data collected during the fourth (2008–2011) and fifth (2011—2014) follow-up examinations. Data related to dietary intake and other covariates were collected from the fourth phase, and incident MetS cases were identified from the fifth phase, which was considered the follow-up phase (Figure 1).

Target population: We selected 3,616 adults aged ≥20 years who were not affected by MetS at the fourth follow-up examination (2008) and who had dietary information (Figure 1). Among this cohort 590 cases of MetS were met our inclusion criteria. All invited participants signed the informed written consent. Ethics approval was obtained from the Shahid Beheshti University of Medical Sciences (SUMS) Research Ethics Board.

Inclusion criteria: Subjects who were eligible for the study included adults aged ≥20 years who had been followed from the fourth to the fifth phase, and who had the following criteria: no history of chronic diseases (diabetes, stroke, thyroid problems and cancer); did not follow any specific dietary regiments (such as a weight loss diet or the intake of fewer than 800 kcal or greater than 4000 kcal per day); and no previous diagnosis of MetS.

Measurement of outcome: MetS was defined according to the recent published consensus guidelines [16] as having at least three of the following criteria: 1) abdominal obesity (waist circumference > 90 cm in both genders, according to the "third National survey of risk factors of noncommunicable diseases (SuRFNCD 2007). This new cut-off was obtained based on the International Diabetes Federation (IDF) criteria. These criteria have shown a sensitivity and specificity of 65%, and positive predictive value of 74% for the diagnosis of MetS. Also, the data were weighted for the following variables: age, gender and residential status)". [17]; 2) serum HDL levels (levels lower than 40 mg/dL in men and 50 mg/dL in women or the consumption of HDL–elevating drugs); 3) hypertension (a systolic BP≥130 mmHg or a diastolic BP≥85 mmHg or the consumption of antihypertensive drugs); 4) hyperglycemia (a fasting blood glucose (FBS) ≥100 mg/dL or the consumption of hypoglycemic drugs); and 5) hypertriglyceridemia (a serum triglyceride level ≥150 mg/dL or the consumption of triglyceride-lowering drugs).

Measurement of exposure: Nutritional data on the participants' dietary intake was collected using a semi-quantitative food frequency questionnaire (FFQ), which consists of 147 food items. Several nutritionists who had been trained in this field completed the questionnaires through face-to-face interviews. During the interview, the average size of each of the FFQ food items (which is equal to one food serving) was described to each participant, and was subsequently asked about the number of times each item was consumed in the previous year. The validity and reliability of the FFQ have been assessed through several studies in Iran and have been found to be acceptable [18, 19] The consumption frequency of each food item in the previous year was assessed on a daily, weekly, monthly or yearly basis. Participants were asked to use food scales to report grams per day of consumption for each food item. The amount of intake of energy and nutrients was determined using a food composition table (See Appendix 1).

Ascertainment of measured variables: Other measured ascertained covariates included: weight, height, age, gender, marital status, history of hospitalization in the previous three months, history of cancer, education (primary, intermediate, high school and high school graduate, academic education) and tobacco use (never smoked, previously smoked, currently smoking). Data were collected using a general information questionnaire administered by a licensed nutritionist. Finally, we used the STROBE checklist to ensure all methodological aspects of the study and appropriately reported and accounted for.

Data analysis: We estimated the effects of food items and nutrients on MetS using both a Bayesian multilevel and conventional analyses. The PROC GLIMMIX in SAS (version 9.4) was used for the Bayesian multilevel analysis. Logistic regression (LR) with two types of variable selection (stepwise-backward selection and selection of all variables) was also applied and their results were compared to the Bayesian multilevel analysis.

In the Bayesian multilevel approach (first analysis), we investigated the concurrent effects on MetS of 95 food items (listed in Appendix 1) and 12 nutrients (carbohydrates, protein, total fat, monounsaturated fatty acids, carotenoids, calcium, folate, magnesium, zinc, fiber, glucose, and fructose), adjusted for nine covariates (age, gender, cancer history, hospitalization status, educational status, body mass index, marital status, smoking history, and calories).

In the first conventional analysis (second analysis, full model), 95 food items and nine covariates were forced into the model. Due to the high correlation between food items and nutrients resulting in the non-convergence of maximum likelihood estimates, the effects of nutrients were not investigated in the conventional analysis.

In the third conventional analysis using stepwise backward selection, the alpha level (level of statistical significance) for selection of food items was set at 0.2 and all nine confounders were forced into the model. Seventy-seven food items were removed at this stage, leaving only 18 food items.

In all three models, the following six food items were removed from the models due to high degree of collinearity between variables (Pearson correlation ≥0.4), retaining the food with a statistically stronger effect (specified in parentheses) in the final analysis: jam (sugar), plum (peach), lemon juice (lemon), apple juice (apple), orange juice (orange), and cooked vegetables (cooked carrots). Moreover, in all the models, 46 food items (data available upon request) were excluded from our analyses because it seemed unlikely that they would have had considerable dietary effects on MetS. Thus 95 [147–(6+46)] food items were retained in the analysis.

To interpret the effects of foods on MetS more easily, each food item variable was transformed from 'grams' to specified servings using valid references based on daily servings [20].

Data analysis was done with Stata 11 (StataCorp, College Station, TX, USA) for the conventional analysis and SAS 9.2 for the Bayesian multilevel approach. The parameters of the logistic regression and Bayesian multilevel models were estimated using maximum likelihood and shrinkage (penalized likelihood) methods, respectively. To compare the precision of estimates, we calculated the difference in confidence limits for odds ratios of foods in the logarithm scale (upper log-odds ratio minus lower log-odds ratio).

Structure of the Bayesian multilevel model

We can write the first stage model as: logit $(p \mid X, W) = \alpha + X\beta + W\gamma$

(1)

In this model, *p* is risk of MetS, ***X*** is the matrix of food items information, ***W*** is the matrix of other potential confounders, and **β** (β1, . . ., β95) is the vector of logistic regression coefficients corresponding to the 95 foods items. The first stage model is also the LR for the conventional analysis.

Second stage (2): $\boldsymbol{\beta}_j = \pi_1 z_{1j} + \pi_2 z_{2j} + \pi_p z_{pj} + \delta_j = \boldsymbol{z}_j \boldsymbol{\pi} + \boldsymbol{\delta}_j$

$$z_j = (z_{1j}, z_{2j}, \dots z_p) \qquad (2)$$

$$\boldsymbol{\delta}_j \sim MVN\ (0, \tau_j)$$

where ***π*** is the vector of coefficients of second-stage covariates for nutrients that may contribute to dietary effects on MetS. These second-stage covariates (***Z***) include nutrients carbohydrates, protein, total fat, monounsaturated fatty acids, carotenoids, calcium, folate, magnesium, zinc, fiber, glucose, and fructose. The quantity δ_j is the residual effect of food item *j*, which is assumed to be an independent normal random variable with zero mean and standard deviation τ_j. Following Witte and Greenland [14], we specified a fixed value of tau to improve estimation convergence. Based on a similar study [14, 21], we set the standard deviation τ_j equal to

0.35 for all food items. This corresponds to having 95% certainty that the odds ratio for the residual effects of foods (per serving of each food) lies between 0.5 and 2.0. The second stage can be interpreted as the prior distribution for the beta coefficients in the Bayesian multilevel method. The second-stage model shrinks the ordinary estimates for food items towards each other when they have similar levels of nutrients.

Models 1 and 2 can be combined into a 'mixed-effects' model

$$logit\ (p|X,\ Z, W) = (\alpha + X(Z\pi + \delta) + W\gamma) = \alpha + XZ\pi + X\delta + W\gamma \quad (3)$$

In this model, $\boldsymbol{\pi}$ and γ are treated as vectors of fixed coefficients, and δ is treated as a vector of random coefficients with mean zero and variance=0.1225. Hence one interpretation is that the multi-level model includes XZ interactions, which allow the effects of X on MetS to be similar when there is a similar nutrient level in the food items.

For the estimation of the fixed and random effects in the Bayesian multilevel model, the Mixed-Model Equations Solution Matrix (MMEQSOl) from SAS GLIMMIX output was used. MMEQSOl contains fixed $\hat{\pi}$, random $\hat{\delta}$, and covariate $\hat{\gamma}$ estimates and their respective estimated covariance matrices. In our study, the MMEQSOl was a 117*117 (95 foods+12 nutrients+ 9 covarites+1 intercept) matrix (Appendix 2).

Patient and public involvement: No patients were involved in the development and design of this prospective study.

RESULTS

The mean (standard deviation **(**SD) age of participants and median follow-up time were 40.6 (12.6) years and 24.6 months, respectively. The total incidence rate of MetS was 82.2 (95% CI: 75.8–89.1) per 10000 person-years. The incidence rate of MetS was higher in males than in females (125.6 vs. 65.3 per 10000 person-years, p<0.001). In both genders, those affected by MetS were older (p<0.001). Also, the percentages of married individuals and those who had previous history of a heart attack were higher among those with MetS than in the non-MetS people (p<0.001) (Table 1).

Conventional analysis

The adjusted odds ratios and corresponding 95% confidence limits (95% CI) for food intakes and other covariates using full logistic regression model and logistic regression model with stepwise backward selection are reported in Table 2. The results of the conventional analysis have been described in details elsewhere [22].

Full model (Logistic regression with all food variables in the model)

Based on this model, two food items were associated with MetS: bananas (OR=1.38, 95%CI: 1.05–1.83), and grapes (OR=1.14, 95%CI: 1.01–1.29). Two other food items that were weakly associated with MetS were beef (OR=1.71, 95%CI: 0.95–3.08), and chicken (OR=1.24, 95%CI: 0.99–1.56). On the other hand, there was a weak evidence of an inverse association of lamb meat (OR=0.44, 95%CI: 0.17–1.12) with MetS.

Logistic regression using backward selection method

In this analysis, only 18 foods remained in the final model. Based on this reduced model, grapes (OR: 1.11, 95%CI: 1.01–1.29; p=0.03) and bananas (OR=1.37, 95%CI: 1.05–1.78; p=0.02) were associated with MetS risk. Also, there was weak evidence of the increase in MetS risk for the intake of rice (OR=1.11, 95%CI: 0.99–1.2; p=0.06), turnip (OR=2.41, 95%CI: 0.77–6.69; p=0.09), and seeds (OR=1.32, 95%CI: 0.99–1.77, p=0.053) . On the other hand, lamb meat was inversely associated with MetS risk (OR: 0.40, 95%CI: 0.16–0.99; p=0.05).

Multi-level Bayesian Analysis via the GLIMMIX

Based on this model, grapes (OR=1.14, 95%CI: 1.01–1.27; p=0.03) and bananas (OR=1.32, 95%CI: 1.01–1.74; p=0.05) were positively associated with MetS. There was also evidence that fructose was positively associated with the MetS risk (OR=1.84, 95%CI: 0.97–3.51; p=0.06) (Table 2).

Upon comparing the three models, 15 (83.3%) of the common odds ratio estimates were the smallest (toward the null) in the Bayesian multilevel model, which is not surprising given that the mean of the residual effects of foods (δ_j) was pre-specified to zero, so the odds ratio estimates underwent shrinkage toward the null. In the remaining three food items (16.7%), the odds ratio estimates were similar between models (Table 2).

DISCUSSION

Although diet may play a role in the etiology of MetS, most previous studies have only looked at a limited number of food items mainly because of limitations of conventional modeling approaches [8-9]. On the other hand, multi-level models and shrinkage estimators are known to give lower prediction error and improve the precision and accuracy of the effect sizes. [14]. This study used novel Bayesian multilevel models to study the simultaneous effects of different food items and related nutrients on the incidence of MetS and compared it to conventional models. Bananas and grapes were the only items that were associated with MetS in all three models. However, upon stratifying by history of diabetes, the effects were weaker in the non-diabetes group. Furthermore, because of the small sample size of the diabetic group (37 new cases of MetS in the 328-populated diabetics group: 0.11 case per event), model fitting in this group failed.

The histogram of regression coefficients of dietary items indicates the penalized likelihood estimates (from GLIMMIX) are much less dispersed than the maximum likelihood estimates in the conventional analyses (Figure 2). Also, GLIMMIX has a better goodness of fit properties than the conventional models as the Deviance Information Criterions (DICs) for backward selection method, full model, and Bayesian multilevel model were 29057.6, 27679.9, and 18122.1, respectively.

The largest odds ratio estimates were observed in the full-model signaling sparse-data bias. The odds ratio estimates in the Bayesian multilevel model were more similar to the logistic regression model with backward selection rather than to the full logistic regression model. For 10 (55.6%) of 18 common odds ratios, the Bayesian multilevel model had the narrowest confidence limits and the highest precision. For seven (38.9%) of odds ratios, the backward model had the best precision whereas there was similar precision for only one (5.6%) of the odds ratios. Although in the backward method only 18 variables remained in the final model, the Bayesian multilevel model outperformed the backward method in terms of precision of the odds ratio estimates.

In the 77 (95 – 18) remaining food items that were common in the Bayesian multilevel models and full model, Bayesian multilevel modeling exhibited better precision (60 (78%) vs. 15 (0.20%)). In two (2%) of odds ratios, both models exhibited similar precision.

In the Bayesian multilevel model, the confidence limits for three extreme odds ratio estimates in the full model were more precise and biologically plausible. Specifically, these odds ratio estimates were as follows: noodle soup ([0.67–2.14] in the Bayesian multilevel model vs. [0.65–5.64] in the full model), beans ([0.5–1.85] vs. [0.03–11.41]), turnip ([0.68–2.23] vs. [0.82–7.52]). In the full model, the estimation for eggplant odds ratio was strongly affected by the sparse data bias [11, 12]: OR=109396, 95% CI=0.152×10^{-6}–768×10^{12}), but this implausible and imprecise estimation was balanced in the Bayesian multilevel model (OR=1.01, 95%CI=0.51–2.00). This balancing of extreme estimates has been shown in previous studies [14, 21].

The most significant limitation of the stepwise backward selection method was the need for the deletion of some variables from the model as the model assumes (with full certainty) that these variables have no effect on the outcome. As such the final selected model does not take into account the uncertainty in the selection procedure. The backward selection method had excluded 77 variables from the final model. This manner of variable selection led to downward bias in the p-values and subsequent standard errors for the reaming variables in the model [23].

Various studies [24, 25] have shown the protective effects of vegetables and fruits on MetS. These nutrients might exert their protective effects potentially through the effects of antioxidants, fiber, potassium and other phyto chemicals, reducing the concentration of CRP (C-Reactive Protein) [26]. However, due to low statistical power of this study, logistic regression models (which usually requires a minimum of 10 events per predictor variable) were deemed underpowered to detect a statistically significant difference for the following food items: vegetables, like kiwifruit, watermelon, apple, cherry, plum, tangerine, dates, nectarine, lemon, tomato, celery, raw onion, cooked cabbage, lettuce and potato.

We observed a weak association between fructose intake and MetS. Some studies [27-29] have shown that the consumption of foods and beverages that are high in fructose facilitate dyslipidemia (increased triglycerides and LDL, and decreased HDL). As previously mentioned [1], hyperlipidemia is considered as one of the components of metabolic syndrome, hence this finding is consistent with earlier studies.

Unlike our study, a study by Esmailzadeh et al. [30-32] have shown the protective effects of whole grains on the incidence of MetS although this study only assessed a limited number of foods and its results might be subject to a number of biases.

One notable limitation of this study was the use of a FFQ to assess food intake. Several studies have shown that the FFQ has limitations in determining dietary patterns- since it encompasses a long list of foods consumed during the past year which may increase the possibility of recall bias. Moreover, the FFQ underestimates the consumption of proteins and carbohydrates allowing the possibility of measurement error [33-35]. Our study had limited statistical power for some of the analysis. The general statistical rule of thumb for sample size calculations suggests that logistic regression models require a minimum of 10 cases per covariate for optimal statistical power [36]. As we estimated the effects of 104 variables (95 food intakes plus 9 confounders), we required 1050 cases to satisfy the criteria for adequate sample size. Unfortunately, we only had 590 new cases of MetS in this study. However, we partially made up for this limitation through the use of the Bayesian multilevel approach. Finally, as with many nutritional epidemiological studies there might be other sources of bias including measurement error, model misspecification, unmeasured confounding, and potential for time-varying confounding [37].

In conclusion, Bayesian multilevel models present more precise and biologically plausible estimates of association than conventional frequentist models and are better able to control for sparse data bias. Despite the complexity of the semi-Bayes models, this model is highly recommended for nutritional studies that involve multiple, correlated and multi-level nutritional exposures.

Ethical approval: Shahid Beheshti University of Medical Sciences (SUMS)/ Research Ethics Board.

Acknowledgments: We thank John Witte for his helpful comments on an earlier draft of this paper. We extend our gratitude to the authorities of the 'Research Institute for Endocrine Sciences' at Shahid Beheshti University of Medical Sciences for sharing their valuable data with us. Moreover, we are grateful to all the participants for availing us their valuable time. The authors also have no conflicts of interest and have no involvement that might raise the question of bias in the results reported here.

Contributorship statement: (Z.Ch conducted research, Z.Ch and N.Mo provided essential reagents or provided essential materials. Z.Ch, S.N, M.A.M and P.M performed the statistical analysis. Z.Ch, S.N, M.A.M, M.E, P.M, and L.Mc wrote the paper. Z.Ch, S.N, M.A.M, P.M, N.Ma, N.Mo, M.E, and L.Mc had primary responsibility for final content; Z.Ch had responsibility for all parts of the manuscript).

Competing interests: None declared.

Funding: This article has been extracted from the first author's Ph.D. thesis (code: 912-112-8002) and was supported by Tehran University of Medical Sciences (TUMS).

Data sharing statement: Data available on request.

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Table 1. Comparison of baseline characteristics of subjects who did and did not develop incident MetS after three years of follow-up

Variables	**Men**			**Women**			**All**		
	Non-MetS (N=1082)	MetS (N=291)	P-v*	Non-MetS (N=1944)	MetS (N=299)	P-v	Non-MetS (N=3026)	MetS (N=590)	P-v
Age (years)	41.60	43.77	0.01	38.87	47.06	<0.001	39.84	45.43	<0.001
BMI (kg/m^2)	26.31	30.67	<0.001	25.41	28.08	<0.001	25.98	29.39	<0.001
Marital status (%)			<0.001			<0.001			<0.001
Married	75.44	86.94		77.28	87.29		75.44	87.12	
Single/Divorced/Widowed	24.65	13.06		22.72	12.71		24.56	12.88	
HMI (%)	0.09	0.69	0.02	0.00	0.33	0.01	0.03	0.51	<0.001
FHDM (%)	6.76	4.48	0.15	11.23	8.03	0.24	9.63	6.28	0.02
Smoking (%)			0.89			0.69			0.13
Never	78.33	78.69		96.55	96.99		90.03	87.97	
Current/Past	21.67	21.31		3.45	3.01		9.97	12.03	
Education level (%)			0.77			<0.001			<0.001
Higher than diploma	41.77	42.61		42.03	22.41		41.94	32.37	
Diploma/below diploma	51.57	51.89		50.82	64.21		51.09	58.14	
Illiterate/Primary school	6.65	5.50		7.15	13.38		6.67	9.49	
Cancer history (%)	0.19	0.34	0.60	0.52	1.34	0.09	0.40	0.85	0.14
Hospitalization (%)	12.04	11.36	0.90	6.25	15.87	0.01	7.66	14.02	0.03

*: The p-value of *t*-test and Chi-squared test; FBS: fasting blood sugar; BMI: body mass index; DM: diabetes mellitus; HMI: history of myocardial infraction disease; FHDM: family history of diabetes mellitus.

Table 2: The effects of food items, nutrients and other covariates on MetS from conventional and Bayesian multilevel (Semi-Bayes) analyses

Variables*	**Comparison group**	**Multiple logistic Regression Model**								
		GLIMMIX			**Backward Selection**			**Full Model**		
		OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
Gender	*Female/male*	0.47	0.38, 0.59	**<0.01**	0.47	0.36, 0.58	**<0.01**	0.46	0.36, 0.58	**<0.01**
Age	*Per 5 years*	1.16	1.11, 1.21	**<0.01**	1.16	1.11, 1.22	**<0.01**	1.16	1.11, 1.22	**<0.01**
Energy	*Per kcal*	1.02	0.98, 1.03	0.85	0.99	1, 1.01	0.10	0.98	1, 1.01	0.53
Cancer History	*Yes vs. no*	2.02	0.59, 6.95	0.26	1.90	0.54, 6.68	0.32	2.00	0.54, 6.68	0.29
Hospitalization	*Yes vs. no*	1.85	0.93, 3.65	0.08	1.96	0.98, 3.90	0.05	1.85	0.98, 3.90	0.09
Smoking	*Yes vs. no*	1.23	0.86, 1.76	0.25	1.23	0.86, 1.77	0.25	1.27	0.86, 1.77	0.21
Body Mass Index	*(kg/m²)*	1.19	1.17, 1.22	**<0.01**	1.19	1.16, 1.22	**<0.01**	1.19	1.16, 1.22	**<0.01**
Education	*Per one degree*	1.34	1.02, 1.76	**0.04**	1.12	0.99, 1.27	0.07	1.34	0.99, 1.27	**0.04**
Marriage	*married vs. single*	1.13	1.01, 1.28	**0.04**	1.34	1.2, 1.78	**0.04**	1.15	1.2, 1.78	**0.05**
Barbari *(Type of Bread)*	*1/4*	1.03	0.67, 1.58	0.89	deleted	-		1.01	0.36, 0.58	0.84
Sangak *(Type of Bread)*	*1/4*	1.00	0.79, 1.26	0.97	deleted	-		1.04	1.11, 1.22	0.71
Taftun *(Type of Bread)*	*1/2*	1.03	0.73, 1.45	0.88	deleted	-		0.97	0.99, 1	0.72
Baguette	*1/2*	0.98	0.79, 1.21	0.83	deleted	-		0.64	0.56, 7.21	0.40
Lavash *(Type of Bread)*	*1*	0.84	0.48, 1.48	0.55	deleted	-		1.07	0.91, 3.76	0.62
Cooked Rice	*1 cup*	1.05	0.83, 1.34	0.66	1.11	0.99, 1.24	0.057	1.10	0.87, 1.84	0.18
Pasta	*1 cup*	1.20	0.77, 1.87	0.43	deleted	-		1.43	1.17, 1.22	0.23
Potato	*1*	0.89	0.54, 1.46	0.65	deleted	-		0.76	0.35, 1.62	0.47
Fried Potato	*10 strip*	1.04	0.78, 1.39	0.79	deleted	-		1.07	0.77, 1.47	0.70
Noodle Soup	*¾ cup*	1.20	0.67, 2.14	0.54	deleted	-		1.51	0.65, 5.64	0.24
Noodle Ash *(Type of soup)*	*1 cup*	0.99	0.57, 1.73	0.98	deleted	-		0.93	0.36, 2.44	0.88
Cracker	*1*	0.94	0.73, 1.22	0.64	deleted	-		0.95	0.71, 1.27	0.73
Corn	*¼ cup*	1.03	0.76, 1.4	0.84	deleted	-		1.02	0.72, 1.45	0.89
Barley	*¼ cup*	1.13	0.74, 1.73	0.58	deleted	-		1.17	0.65, 2.08	0.60
Lentil	*½ cup*	1.10	0.76, 1.59	0.62	deleted	-		1.23	0.86, 1.75	0.26

Variables*	Comparison group	Multiple logistic Regression Model								
		GLIMMIX			Backward Selection			Full Model		
		OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Beans	*½ cup*	1.06	0.64, 1.75	0.83	deleted	-		1.03	0.45, 2.36	0.95
Pea	*½ cup*	1.25	0.77, 2.04	0.37	1.66	0.88, 3.09	0.11	1.55	0.71, 3.38	0.27
Bean	*2 cup*	0.96	0.5, 1.85	0.91	deleted	-		0.55	0.03, 1.41	0.70
Soya	*½ cup*	0.80	0.48, 1.3	0.36	deleted	-		0.67	0.3, 1.51	0.34
Cotyledon	*1 cup*	1.02	0.57, 1.83	0.96	deleted	-		0.97	0.29, 3.27	0.96
Lamb Meat	*2 oz*	0.77	0.45, 1.33	0.34	0.40	0.16, 0.99	0.05	0.44	0.17, 1.12	0.09
Beef	*2 oz*	1.39	0.88, 2.19	0.16	1.54	0.88, 2.71	0.13	1.71	0.95, 3.08	0.08
Ground beef	*2 oz*	0.88	0.53, 1.47	0.63	deleted	-		0.79	0.35, 1.76	0.56
Chicken	*3.5 oz*	1.24	0.87, 1.78	0.24	1.19	0.96, 1.48	0.10	1.24	0.99, 1.56	0.06
Fish	*3.5 oz*	1.02	0.77, 1.34	0.90	deleted	-		1.00	0.87, 1.14	0.97
Canned Fish	*3.5 oz*	0.98	0.53, 1.8	0.94	deleted	-		0.91	0.23, 3.53	0.89
Sausage	*100 gr*	0.88	0.46, 1.7	0.71	deleted	-		0.26	0.02, 3.15	0.29
Egg	*1*	1.00	1, 1	0.78	deleted	-		1.00	1, 1	0.79
Pizza	*100 gr*	0.96	0.62, 1.48	0.85	deleted	-		0.94	0.55, 1.62	0.83
Low-Fat Milk	*1 cup*	1.00	0.8, 1.26	0.99	deleted	-		1.04	0.84, 1.27	0.74
Whole-Fat Milk	*1 cup*	0.97	0.77, 1.21	0.77	deleted	-		1.00	0.81, 1.23	0.98
Chocolate Milk	*1 cup*	1.10	0.75, 1.63	0.62	deleted	-		1.22	0.77, 1.94	0.39
Yogurt	*½ cup*	1.08	0.84, 1.39	0.56	deleted	-		1.12	0.88, 1.43	0.34
Strain Yogurt	*1 cup*	0.93	0.76, 1.13	0.47	deleted	-		0.96	0.83, 1.11	0.58
Whole Fat Yogurt	*1 cup*	0.90	0.71, 1.14	0.37	deleted	-		0.91	0.73-1.12	0.37
Cheese	*1 oz*	1.06	0.9, 1.25	0.47	1.10	0.96, 1.27	0.15	1.09	0.93-1.28	0.26
Whole-Fat Cheese	*2 oz*	0.85	0.5, 1.43	0.53	deleted	-		0.63	0.26-1.52	0.31
Yogurt Drink	*1 cup*	1.08	0.77, 1.51	0.65	deleted	-		1.15	0.82, 1.61	0.43
Traditional Ice Cream	*1 cup*	1.04	0.64, 1.7	0.86	deleted	,		1.10	0.54-2.25	0.79
Butter	*1 cup*	0.92	0.6, 1.42	0.72	deleted	-		0.85	0.49-1.46	0.56
Shredded Lettuce	*1.5 cup*	0.84	0.56, 1.26	0.39	deleted			0.75	0.44-1.29	0.30
Tomato	*1*	0.99	0.8, 1.21	0.91	0.89	0.77, 1.2	0.12	0.89	0.75, 1.05	0.18
Cucumbers	*1*	1.05	0.91, 1.21	0.52	deleted	-		1.06	0.9, 1.24	0.48

Variables*	Comparison group	Multiple logistic Regression Model								
		GLIMMIX			Backward Selection			Full Model		
		OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Vegetables	*1.5 cup*	1.24	0.72, 2.11	0.44	deleted	-		1.62	0.67, 3.9	0.28
Eggplant	*3.5 oz*	1.01	0.51, 2	0.98	deleted	-		109396	0, 79*10^15	0.41
Cooked Celery	*1/3 cup*	0.95	0.52, 1.76	0.88	deleted	-		0.71	0.16, 3.11	0.65
Green Peas Cooked	*½ cup*	0.82	0.45, 1.47	0.50	0.41	0.12, 1.44	0.14	0.38	0.09, 1.58	0.18
Green Beans Cooked	*¼ cup*	0.98	0.64, 1.5	0.93	deleted	-		1.11	0.61, 2.02	0.73
Raw Carrots	*1*	1.01	0.67, 1.53	0.95	deleted	-		0.87	0.56, 1.35	0.54
Cooked Carrots	*½ cup*	1.04	0.61, 1.78	0.88	deleted	-		0.81	0.39, 1.68	0.57
Raw Onion	*1/3 cup*	0.94	0.69, 1.28	0.70	deleted	-		0.88	0.61, 1.28	0.50
Fried Onions	*½ cup*	1.06	0.73, 1.53	0.78	deleted	-		1.03	0.65, 1.62	0.91
Cabbage	*½ cup*	0.91	0.72, 1.17	0.48	deleted	-		0.90	0.68, 1.19	0.47
Green Pepper	*½ cup*	1.06	0.68, 1.66	0.80	deleted	-		1.05	0.57, 1.93	0.87
Cooked Spinach	*½ cup*	1.09	0.62, 1.91	0.76	deleted	-		0.90	0.36, 2.25	0.82
Turnip	*2/3 cup*	1.23	0.68, 2.23	0.49	2.41	0.77, 6.69	0.09	2.48	0.82, 7.52	0.11
Ketchup	*1 sp*	0.97	0.64, 1.46	0.88	deleted	-		0.91	0.54, 1.53	0.73
Pickle	*2 sp*	1.04	0.88, 1.23	0.66	deleted	-		1.05	0.91, 1.22	0.51
Cantaloupe	*1*	1.10	0.81, 1.51	0.54	deleted	-		1.07	0.75, 1.54	0.70
Melon	*1*	1.00	0.69, 1.45	0.98	deleted	-		1.01	0.63, 1.63	0.96
Watermelon	*¾ cup*	0.98	0.74, 1.3	0.91	deleted	-		0.90	0.71, 1.14	0.38
Pear	*1*	1.04	0.72, 1.51	0.81	deleted	-		1.05	0.66, 1.67	0.84
Cherry	*15*	0.95	0.83, 1.09	0.44	deleted	-		0.93	0.8, 1.09	0.38
Apple	*1*	0.88	0.7, 1.1	0.26	deleted	-		0.95	0.77, 1.18	0.65
Peach	*1*	1.06	0.73, 1.52	0.77	deleted	-		1.19	0.7, 2.04	0.52
Nectarine	*1*	0.88	0.51, 1.54	0.67	deleted	-		0.49	0.11, 2.19	0.35
Grape	*25*	1.14	1.01, 1.27	0.03	1.11	1.0, 1.29	0.03	1.14	1.01, 1.29	0.03
Kiwi	*1*	0.85	0.51, 1.4	0.51	0.58	0.31, 1.29	0.12	0.64	0.29, 1.4	0.26
Orange	*1*	1.05	0.85, 1.29	0.66	deleted	-		1.06	0.85, 1.32	0.59
Persimmon	*1*	1.09	0.81, 1.49	0.56	deleted	-		1.07	0.76, 1.52	0.70

Variables*	Comparison group	Multiple logistic Regression Model								
		GLIMMIX			Backward Selection			Full Model		
		OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Tangerine	*1*	0.85	0.63, 1.15	0.29	deleted	-		0.84	0.6, 1.19	0.34
Pomegranate	*1*	1.04	0.79, 1.37	0.75	deleted	-		1.01	0.79, 1.3	0.93
Date	*4*	0.99	0.69, 1.44	0.97	deleted	-		0.97	0.63, 1.49	0.88
Plum	*4*	0.93	0.56, 1.54	0.78	deleted	-		0.82	0.36, 1.86	0.64
Banana	*1*	1.32	1, 1.74	0.05	1.37	1.05,1.78	0.02	1.38	1.05, 1.83	0.02
Lemon	*1*	0.88	0.66, 1.17	0.38	deleted	-		0.87	0.62, 1.21	0.40
Sour Lemon	*1*	0.93	0.63, 1.37	0.71	deleted	-		0.90	0.54, 1.48	0.67
Cantaloupe Juice	*½ cup*	1.08	0.83, 1.41	0.57	deleted	-		1.07	0.79, 1.44	0.66
Packaged Fruit Juices	*4 sp*	1.11	0.94, 1.32	0.22	deleted	-		1.11	0.92, 1.33	0.26
Solid Oils	*4 sp*	1.13	0.67, 1.9	0.64	deleted	-		1.08	0.58, 2	0.81
Liquid Oil	*2 sp*	0.83	0.5, 1.37	0.46	0.58	0.28, 1.24	0.16	0.58	0.26, 1.3	0.19
Mayonnaise	*1 sp*	1.23	0.83, 1.82	0.29	1.36	0.89, 2.23	0.17	1.42	0.86, 2.36	0.18
Almonds	*4*	1.08	0.59, 1.97	0.81	deleted	-		1.06	0.3, 3.81	0.93
Walnut	*2*	1.04	0.69, 1.56	0.84	deleted	-		1.03	0.61, 1.74	0.92
Pistachios	*¼ cup*	1.02	0.72, 1.45	0.89	deleted	-		0.94	0.54, 1.63	0.82
Seeds	*½ cup*	1.28	0.88, 1.88	0.20	1.32	0.99, 1.77	0.053	1.33	0.99, 1.79	0.06
Sugar	*10*	0.84	0.47, 1.5	0.56	deleted	-		0.55	0.19, 1.62	0.28
Sugar Loaf	*5 sp*	0.80	0.43, 1.51	0.50	0.32	0.07, 1.33	0.12	0.27	0.05, 1.39	0.12
Honey	*2 sp*	1.02	0.69, 1.49	0.94	deleted	-		1.01	0.65, 1.56	0.98
Cola Drink	*1 cup*	1.18	0.84, 1.67	0.34	1.26	0.92, 1.73	0.15	1.34	0.94, 1.9	0.10
Tea	*1 cup*	0.99	0.94, 1.05	0.82	deleted	-		1.01	0.96, 1.06	0.69
Chips	*10 strip*	0.79	0.46, 1.35	0.39	0.52	0.22, 1.28	0.16	0.49	0.19, 1.28	0.15
Coffee	*½ cup*	0.97	0.82, 1.14	0.68	deleted			0.98	0.82, 1.17	0.85
Baked Mushrooms	*1 cup*	1.11	0.79, 1.55	0.56	deleted	-	-	1.18	0.79, 1.77	0.42
Salt	*1 gr*	1.02	0.97, 1.06	0.46	deleted	-	-	1.02	0.98, 1.07	0.35
Protein	*50 gr*	0.89	0.49, 1.62	0.69	-	-	-		-	-
Carbohydrates	*100 gr*	0.85	0.31, 2.33	0.76	-	-	-		-	-
Total Fat	*20 gr*	0.96	0.58, 1.59	0.87	-	-	-		-	-

Variables*	Comparison group	Multiple logistic Regression Model								
		GLIMMIX			Backward Selection			Full Model		
		OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Mon Saturate-Fatty Acids	*10 gr*	0.93	0.73, 1.18	0.53	-	-	-		-	-
Carotenoids	*2 gr*	1.00	1, 1	0.29	-	-	-		-	-
Calcium	*100 gr*	1.14	0.69, 1.89	0.6	-	-	-		-	-
Folates	*400 gr*	1.23	0.51, 2.96	0.65	-	-	-		-	-
Magnesium	*350 gr*	1.20	0.47, 3.05	0.7	-	-	-		-	-
Zink	*10 gr*	0.87	0.68, 1.11	0.26	-	-	-		-	-
Total Fiber	*30 gr*	0.96	0.71, 1.29	0.77	-	-	-		-	-
Glucose	*20 gr*	0.50	0.2, 1.27	0.15	-	-	-		-	-
Fructose	*20 gr*	1.84	0.97, 3.51	0.06	-	-	-		-	-

†Semi-Bayes (Bayesian Multi-Level) included all 95 foods, all 12 nutrients, and nine covariates, we set $\tau_i = 0.35$ for each food.
§ Backward selection entered all 95 foods but no nutrients. 18 foods and seven covariates were retained and 77 foods deleted, α-to-remove =0.2
§§ Full Model entered all 95 foods and nine covariates, but no nutrients.
*for the 95 foods, the comparisons are serving of each foods vs. none per day.

Figure 1: Follow up the status of the TLGS participants after the baseline examination. MetS: Metabolic Syndrome, TLGS: Tehran and Lipid and Glucose study
Figure 2: Histogram of maximum-Likelihood and penalized-likelihood coefficients for the effects of dietary items on metabolic syndrome

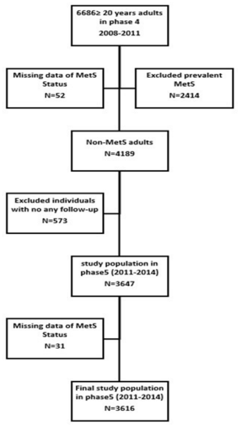

Figure 1: Follow up the status of the TLGS participants after the baseline examination. MetS: Metabolic Syndrome, TLGS: Tehran and Lipid and Glucose study

115x57mm (300 x 300 DPI)

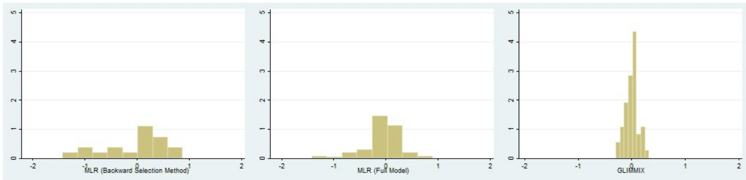

Figure 2: Histogram of maximum-Likelihood and penalized-likelihood coefficients for the effects of dietary items on metabolic syndrome.

115x52mm (300 x 300 DPI)

The SAS System

The Mixed Procedure

Model Information	
Data Set	WORK._DS
Dependent Variable	_z
Weight Variable	_w
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Parameter
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Containment

Dimensions	
Covariance Parameters	1
Columns in X	22
Columns in Z	95
Subjects	1
Max Obs Per Subject	3616

Number of Observations	
Number of Observations Read	3616
Number of Observations Used	3542
Number of Observations Not Used	74

Parameter Search		
CovP1	Res Log Like	-2 Res Log Like
0.9354	-9177.0443	18354.0886

Iteration History			
Iteration	Evaluations	-2 Res Log Like	Criterion
1	1	18354.08857989	0.00000000

Convergence criteria met.

Covariance Parameter Estimates	
Cov Parm	Estimate
Residual	0.9354

Row	Effect	Col1	Col2	Col3	Col4	Col5	Col6	Col7	Col8	Col9	Col10	Col11	Col12	Col13	Col14	Col15	Col16	Col17	Col18
1	Intercept	0.3429	-0.00602	0.004469	-0.00208	-0.00867	-0.04320	-0.00361	-0.02612	-0.02006	-0.00003	-0.00446	-0.00088	-0.00033	0.002136	6.634E-7	-0.00174	-0.01175	0.009079
2	age	-0.00602	0.000516	-0.00086	0.000068	0.000243	0.000087	0.000018	-0.00054	0.000467	-1.05E-6	0.000296	0.000146	0.000075	-0.00006	-2.85E-8	0.000350	0.000322	-0.00074
3	cancer	0.004469	-0.00086	0.3968	-0.00346	-0.00541	-0.00230	0.000131	0.002893	-0.00007	9.033E-6	0.000689	-0.00013	-0.00035	0.000183	-2.33E-7	-0.00320	-0.00058	0.001154
4	hospital	-0.00208	0.000068	-0.00346	0.1209	-0.00041	0.000670	0.000060	-0.00151	0.000218	-0.00007	0.001583	0.002675	0.001292	-0.00045	-1.11E-7	0.000730	0.001446	-0.00145
5	sex	-0.00867	0.000243	-0.00541	-0.00041	0.01282	0.004361	-0.00024	-0.00011	0.000371	0.000022	0.000416	0.000260	-0.00018	-0.00053	-5.16E-8	-0.00052	-3.9E-6	-0.00093
6	smok	-0.04320	0.000087	-0.00230	0.000670	0.004361	0.03289	0.000110	-0.00022	0.000755	-0.00003	-0.00166	0.000702	0.000481	-0.00020	-1.06E-7	-0.00126	0.001234	0.003540
7	bmi	-0.00361	0.000018	0.000131	0.000060	-0.00024	0.000110	0.000128	-0.00018	0.000080	-3.26E-6	0.000056	0.000157	0.000084	-0.00008	-6.09E-9	-0.00003	0.000066	-0.00001
8	marriag	-0.02612	-0.00054	0.002893	-0.00151	-0.00011	-0.00022	-0.00018	0.01956	0.000044	0.000043	-0.00006	-0.00216	-0.00101	0.000370	4.391E-8	-0.00051	0.000045	0.000686
9	edu	-0.02006	0.000467	-0.00007	0.000218	0.000371	0.000755	0.000080	0.000044	0.003922	-2.45E-6	0.000211	-0.00012	0.000097	-0.00009	-5.43E-8	0.000426	0.001175	-0.00089
10	kcal10	-0.00003	-1.05E-6	9.033E-6	-0.00007	0.000022	-0.00003	-3.26E-6	0.000043	-2.45E-6	0.000157	-0.00187	-0.00607	-0.00304	0.000408	4.844E-8	-0.00033	-0.00188	0.000917
11	protein50	-0.00446	0.000296	0.000689	0.001583	0.000416	-0.00166	0.000056	-0.00006	0.000211	-0.00187	0.09397	0.06827	0.03682	-0.00920	5.364E-7	0.006282	0.003549	-0.04876
12	cho100	-0.00088	0.000146	-0.00013	0.002675	0.000260	0.000702	0.000157	-0.00216	-0.00012	-0.00607	0.06827	0.2638	0.1185	-0.01872	-9.04E-7	0.01101	0.04694	-0.03988
13	fat20	-0.00033	0.000075	-0.00035	0.001292	-0.00018	0.000481	0.000084	-0.00101	0.000097	-0.00304	0.03682	0.1185	0.06568	-0.01569	-8.26E-8	0.01178	0.03373	-0.03715
14	msf10	0.002136	-0.00006	0.000183	-0.00045	-0.00053	-0.00020	-0.00008	0.000370	-0.00009	0.000408	-0.00920	-0.01872	-0.01569	0.01478	-4.94E-7	-0.00587	0.000586	0.01700
15	carotenoids2	6.634E-7	-2.85E-8	-2.33E-7	-1.11E-7	-5.16E-8	-1.06E-7	-6.09E-9	4.391E-8	-5.43E-8	4.844E-8	5.364E-7	-9.04E-7	-8.26E-8	-4.94E-7	1.698E-9	-5.69E-6	-3.69E-6	-2.09E-6
16	calcium1000	-0.00174	0.000350	-0.00320	0.000730	-0.00052	-0.00126	-0.00003	-0.00051	0.000426	-0.00033	0.006282	0.01101	0.01178	-0.00587	-5.69E-6	0.06572	0.01472	-0.05752
17	folate400	-0.01175	0.000322	-0.00058	0.001446	-3.9E-6	0.001234	0.000066	0.000045	0.001175	-0.00188	0.003549	0.04694	0.03373	0.000586	-3.69E-6	0.01472	0.2017	-0.06997
18	mg350	0.009079	-0.00074	0.001154	-0.00145	-0.00093	0.003540	-0.00001	0.000686	-0.00089	0.000917	-0.04876	-0.03988	-0.03715	0.01700	-2.09E-6	-0.05752	-0.06997	0.2267
19	zinc10	-0.00088	-0.00001	-0.00019	-0.00018	0.000178	0.000550	0.000017	-0.00016	0.000044	0.000078	-0.00556	-0.00245	-0.00094	-0.00093	-1.27E-8	-0.00493	-0.00425	-0.00597
20	fiber30	0.001372	-0.00014	0.000448	-0.00025	0.000482	0.000185	-5.68E-6	-5.12E-6	-0.00031	0.000502	-0.01180	-0.02077	-0.00862	0.000870	3.006E-7	-0.00838	-0.02194	-0.00178
21	glucose20	-0.00165	-0.00005	-0.00258	0.001179	-0.00017	0.001239	0.000071	-0.00040	0.000496	-0.00163	0.03804	0.03801	0.02914	0.000244	-2.45E-6	-0.00388	0.003080	-0.03394
22	fructose20	0.001286	-0.00005	0.000619	5.778E-6	0.000200	-0.00064	-0.00004	0.000260	-0.00008	0.001478	-0.03026	-0.05694	-0.02565	-0.00014	2.537E-7	0.01300	-0.00052	0.02361

Row	Effect	Col1	Col2	Col3	Col4	Col5	Col6	Col7	Col8	Col9	Col10	Col11	Col12	Col13	Col14	Col15	Col16	Col17	Col18
23	lavash	0.003067	-0.00015	0.000396	-0.00011	-0.00070	-0.00029	-0.00002	0.000423	0.000126	-0.00042	0.01122	0.009868	0.006726	0.000563	1.701E-6	-0.00494	-0.02484	0.03517
24	barbari	0.000482	0.000057	-0.00004	0.000277	-0.00014	-0.00034	-0.00002	-0.00003	0.000276	-0.00028	0.005344	0.003642	0.009631	-0.00316	7.485E-7	0.01205	0.01641	-0.03710
25	sangak	0.001348	0.000048	-0.00120	-0.00047	-0.00032	-0.00052	-0.00003	0.000031	0.000170	-0.00045	0.008445	0.006437	0.01520	-0.00488	1.186E-6	0.01790	0.02539	-0.05666
26	taftun	0.000252	0.000035	0.000616	-0.00009	-0.00022	-0.00074	-0.00001	-0.00007	0.000232	-0.00026	0.005311	0.003641	0.008774	-0.00278	7.343E-7	0.01018	0.01410	-0.03206
27	budget	0.000171	0.000149	0.000195	0.000935	-8.98E-6	-0.00063	-0.00005	0.000274	0.000021	0.000113	-0.00310	-0.00643	-0.00118	-0.00045	5.51E-7	-0.00189	-0.02443	0.01107
28	rice	-0.00017	0.000018	0.000010	0.000132	-0.00004	0.000483	2.725E-6	-0.00009	-0.00024	0.000105	0.001656	-0.01241	-0.00092	-0.00008	5.467E-7	0.000094	-0.03099	0.01127
29	pasta	-0.00502	0.000249	0.000911	0.000663	0.000451	0.000997	0.000034	-0.00013	-0.00022	-0.00003	0.000030	-0.00141	0.001426	-0.00074	2.951E-7	-0.00010	-0.01156	0.002606
30	potato	-0.00106	-0.00027	0.002736	0.000688	0.000030	0.000280	0.000072	0.000054	0.000277	-0.00008	0.001598	-0.00081	0.002588	-0.00075	1.535E-7	0.002163	0.000172	-0.00485
31	friedpo	-0.00029	0.000101	0.000241	0.000192	-0.00001	0.000312	-0.00001	-0.00014	-0.00002	-0.00007	0.001530	0.000326	0.001386	-0.00038	-5.57E-8	0.001151	0.004005	-0.00121
32	soupnoodl	0.001262	-0.00018	0.000641	0.000277	0.000788	0.000886	0.000035	-0.00049	-0.00019	0.000079	-0.00070	-0.00512	-0.00061	-0.00054	-5.71E-8	0.001669	-0.01410	0.003156
33	ashnoodl	-0.00009	-0.00011	0.000814	-0.00023	-0.00014	0.001075	0.000023	-0.00006	0.000015	0.000014	-0.00151	-0.00307	0.000769	-0.00030	3.475E-8	0.000812	-0.01647	0.002892
34	biscuit	0.000697	0.000087	-0.00015	0.001599	-0.00067	-0.00036	-0.00004	0.000561	-0.00027	-0.00011	0.000644	0.001172	0.002744	-0.00085	3.6E-7	-0.00054	0.007710	-0.00475
35	corn	-0.00025	0.000072	0.001012	0.000382	-0.00019	-0.00023	-1.6E-6	-0.00042	0.000029	4.617E-6	0.000161	-0.00002	-0.00026	0.000340	9.585E-8	-0.00022	0.000163	0.000346
36	barley	0.000710	-0.00015	0.001279	-0.00074	-0.00039	0.000688	0.000015	0.000036	0.000016	-0.00007	0.000429	0.001030	0.001901	-0.00051	-1.69E-7	0.002543	-0.00456	-0.00028
37	lentil	0.000252	-0.00007	-0.00181	-0.00026	-0.00083	0.000267	0.000023	0.000074	-0.00016	0.000240	-0.00183	-0.00540	-0.00313	-0.00073	7.04E-7	0.002094	-0.04246	0.01134
38	bean	-0.00328	-0.00011	-0.00021	-0.00140	0.000592	0.001328	0.000041	0.000179	-0.00020	0.000026	0.000765	-0.00085	0.000939	-0.00136	4.71E-7	0.000638	-0.01467	-0.00024
39	pea	0.002455	-0.00012	0.000459	0.001802	-0.00011	-0.00085	-0.00002	0.000103	-0.00014	0.000104	0.000213	-0.00128	-0.00057	-0.00080	5.224E-7	0.002206	-0.03085	0.004053
40	cookedbean	-0.00065	-0.00001	-0.00046	0.000121	0.000101	0.000366	0.000014	-0.00009	-0.00002	0.000012	-0.00003	-0.00011	0.000283	-0.00053	1.44E-8	0.001370	-0.00830	0.001274
41	soybean	0.002983	-0.00013	-0.00127	-0.00018	-0.00031	0.000339	-0.00003	0.000344	-0.00016	4.693E-6	-0.00929	0.005082	0.001802	-0.00109	6.155E-7	0.005946	-0.02624	-0.00085
42	cotyledon	-0.00163	-0.00006	-0.00076	0.000049	0.000724	-0.00014	0.000026	-0.00029	0.000056	-0.00007	-0.00012	0.002663	0.002371	-0.00122	1.956E-7	0.002274	-0.00725	-0.00116
43	beef	0.004291	-0.00002	-0.00185	0.000480	0.000224	-0.00109	-0.00006	0.000514	-0.00066	-0.00034	-0.00585	0.01382	0.006990	-0.00106	-1.86E-7	0.001194	0.007220	0.003190
44	lambmeat	-0.00048	0.000145	-0.00006	0.001420	-0.00047	0.000870	0.000038	-0.00070	-0.00020	-0.00044	-0.00625	0.01748	0.008736	-0.00141	-2.52E-7	0.001675	0.008881	0.003260
45	groundbeef	0.001322	-0.00003	0.002130	-0.00049	-0.00123	-0.00015	0.000094	-0.00123	-0.00057	-0.00030	-0.00858	0.01217	0.006168	-0.00220	-3.45E-7	0.000993	0.005541	0.005705
46	chickens	0.001997	-0.00015	0.000379	-0.00036	-0.00013	0.000914	-0.00002	-0.00015	-0.00005	-0.00092	-0.02437	0.03653	0.01837	-0.00179	-8.99E-7	0.004159	0.02529	0.004300
47	fish	0.001588	-0.00006	-0.00037	0.000148	-0.00021	0.000678	0.000016	-0.00054	-0.00003	-0.00075	-0.01860	0.03294	0.01589	-0.00215	-3.16E-7	0.004225	0.01704	-0.00379
48	fishcanned	-0.00393	0.000122	0.001446	0.000303	0.000286	0.000185	1.443E-6	0.000530	0.000439	-0.00022	-0.00461	0.009076	0.004602	-0.00028	1.541E-7	0.000419	0.003105	-0.00136
49	sausage	-0.00260	0.000145	-0.00006	-0.00006	0.000067	-0.00009	-6.32E-7	0.000524	-0.00005	-0.00013	-0.00061	0.004890	0.002812	-0.00141	-2.77E-8	0.000388	0.000898	0.001534
50	egg	-0.00004	2.897E-6	-0.00009	-7.97E-7	0.000013	7.758E-7	-7.9E-7	7.857E-6	-7.24E-7	-2.59E-6	-0.00006	0.000118	0.000048	-0.00001	-1.79E-9	-5.86E-6	-0.00004	0.000095
51	pizza	-0.00148	0.000248	-0.00216	0.000232	-5.05E-6	0.000571	-0.00005	0.000042	-0.00023	-0.00028	-0.00860	0.008394	0.005733	-0.00167	3.539E-7	-0.00391	-0.00142	0.01264
52	lowfatmilk	-0.00058	-0.00014	0.001906	0.000119	-0.00027	0.000560	-2.69E-6	0.000289	0.000047	-0.00015	-0.00617	0.005159	0.002475	0.000753	1.366E-6	-0.01320	0.003599	0.008090
53	wholmilk	-0.00173	-0.00006	-0.00021	0.000321	-0.00043	0.000207	0.000025	0.000096	0.000053	-0.00015	-0.00484	0.003807	0.001201	0.001357	1.101E-6	-0.01364	0.004772	0.01263
54	chocolatmilk	-0.00302	0.000174	-0.00209	0.001357	0.000192	0.000051	0.000016	0.000593	-0.00016	-0.00013	-0.00156	-0.00005	0.002954	0.000046	1.291E-6	-0.00684	0.01125	-0.00658
55	yogurt	0.001875	-0.00005	-0.00115	-0.00037	0.000103	0.000595	-0.00004	0.000399	0.000193	-0.00019	-0.00864	0.001889	0.001378	0.003002	-5.45E-7	-0.00155	0.01051	0.01174
56	regularyogurt	0.000488	-0.00012	0.000128	0.000580	0.000121	0.000735	-7.47E-6	0.000087	-0.00010	-0.00016	-0.00574	0.004994	0.002331	0.000583	1.579E-6	-0.01583	0.000561	0.01185
57	fullfatyogurt	0.000797	-0.00002	0.001307	0.000666	0.000174	-0.00014	-1.16E-6	-0.00059	-0.00001	-0.00035	-0.00161	0.01132	0.005050	0.000564	1.121E-6	-0.01428	0.009583	0.009007
58	cheese	-0.00069	-0.00007	0.000917	-0.00033	-0.00008	0.000061	-4.91E-6	0.000081	-0.00005	-0.00004	-0.00365	0.002497	-0.00086	0.001501	5.542E-7	-0.00910	-0.00244	0.01377
59	creamcheese	0.002143	-0.00007	-0.00176	-0.00074	0.000645	0.000820	-0.00001	0.000089	-0.00015	-0.00001	-0.00105	0.000675	-0.00100	-0.00023	-2.1E-7	-0.00272	-0.00103	0.009508
60	buttermilk	0.000226	-0.00007	0.002431	-0.00085	0.000293	0.000603	7.374E-6	-0.00038	8.822E-6	-0.00020	-0.00637	0.006531	0.002803	0.001052	1.768E-6	-0.01706	0.001757	0.01382
61	traditionalicream	0.000679	-0.00011	0.000972	0.000929	0.000979	0.000663	-0.00002	0.000240	-0.00009	-0.00016	0.000936	0.001827	0.001429	-0.00009	1.9E-8	-0.00553	0.005650	0.009903
62	butter	-0.00376	0.000045	-0.00054	0.001830	0.000732	-0.00028	0.000113	0.000377	-0.00009	0.000013	0.002390	-0.00157	-0.00439	0.000403	-8.26E-7	-0.00592	-0.00078	0.01993
63	shreddedlettuce	0.000265	-0.00006	0.002806	0.001717	0.000746	0.000719	-0.00005	0.000520	-0.00031	0.000083	-0.00096	-0.00046	-0.00126	-0.00012	-1.25E-7	-0.00042	-0.01622	0.005770
64	tomato	0.000528	-0.00005	-0.00237	-0.00050	-0.00015	0.000015	-0.00003	-0.00027	0.000045	-0.00006	-0.00054	0.002646	-0.00007	0.000494	-2.92E-6	0.01106	0.003437	0.001601
65	cucumber	0.000655	0.000019	0.001570	-0.00106	-0.00048	0.000112	-0.00003	0.000122	-0.00004	0.000013	0.000617	0.000188	0.000270	-0.00035	5.371E-8	0.001931	-0.00054	-0.00445
66	eatingvegetabl	-0.00310	-0.00043	0.003023	-0.00008	-0.00059	0.000925	-2.94E-6	0.001063	0.000811	0.000056	-0.00224	-0.00177	-0.00055	-0.00061	-5.41E-7	-0.00058	-0.00056	-0.00016
67	bakedeggplant	-0.00020	-2.21E-6	0.000012	-0.00002	-7.05E-6	0.000022	2.7E-6	6.888E-6	0.000023	-2.14E-6	9.321E-6	-0.00005	0.000021	0.000023	-2.64E-8	0.000040	0.000122	-0.00003
68	bakedcelery	0.000790	-0.00019	0.000073	0.000570	-0.00017	0.000217	-0.00003	0.000753	-0.00006	0.000017	-0.00002	-0.00052	-0.00031	0.000325	-4.68E-7	0.001659	-0.00286	-0.00048
69	greenpeascooked	0.002945	-0.00009	0.002231	0.001310	-0.00022	-0.00037	-0.00005	-0.00010	0.000053	0.000030	0.000618	-0.00019	-0.00065	0.000279	-5.34E-7	0.004141	-0.00804	-0.00063
70	greenbeanbaked	0.000230	-0.00014	0.000287	-0.00132	-0.00067	-0.00017	2.326E-6	-0.00008	0.000177	-0.00008	0.002543	0.003754	0.001572	-0.00014	-3.68E-7	0.002248	-0.00208	-0.00444
71	rawcarrots	0.001367	0.000107	0.002281	-0.00111	-0.00062	0.000163	-0.00005	-0.00017	0.000043	-0.00003	-0.00210	-0.00114	-0.00137	0.001332	-4.58E-6	0.01463	0.005142	0.006291
72	bakedcarrots	0.000390	-0.00010	0.000158	0.000437	-0.00047	0.000512	-0.00001	-0.00023	0.000088	-0.00007	-0.00275	-0.00069	-0.00069	0.001311	-4.83E-6	0.01579	0.007318	0.007364
73	rawonion	0.004305	-0.00024	-0.00029	-0.00213	0.000768	-0.00005	-0.00010	0.000122	-0.00024	0.000016	-0.00088	0.000258	-0.00015	-0.00018	2.99E-8	0.000600	-0.00309	0.001616
74	friedonion	0.002483	0.000065	0.001403	-0.00039	-0.00370	-0.00053	0.000048	-0.00085	0.000215	0.000078	-0.00078	-0.00516	-0.00126	-0.00155	-1.03E-7	-0.00078	-0.00826	0.006920
75	cabbage	-0.00195	-0.00001	-0.00062	-0.00144	-0.00007	-0.00018	-0.00003	-0.00035	0.000241	-0.00001	0.000336	0.000582	0.000292	-0.00009	7.539E-8	-0.00041	0.000245	0.000509
76	bellpeppers	0.002122	-0.00006	0.002687	0.001861	-0.00139	0.000204	0.000017	-0.00003	0.000104	-0.00004	-0.00055	0.003309	0.000248	-0.00021	-9.26E-7	0.005575	-0.00508	0.000137
77	cookedspinach	0.002002	-0.00012	-0.00049	0.000558	-0.00028	-0.00037	-0.00002	-0.00003	0.000026	-0.00001	-0.00036	0.000880	-0.00033	0.000490	-2.66E-6	0.01060	-0.00443	0.000325
78	turnip	0.000423	-8.12E-6	0.001232	0.001180	-0.00033	-0.00006	0.000010	0.000154	-0.00009	0.000075	0.000852	-0.00335	-0.00149	0.000336	1.924E-7	-0.00083	-0.00019	-0.00025
79	ketchup	-0.00319	0.000292	-0.00491	0.001547	0.000904	0.000697	8.896E-7	0.000313	-0.00046	-0.00008	-0.00118	0.001801	0.000544	0.000294	-1.91E-6	0.006304	0.002361	0.004992
80	torshi	-0.00006	-2.53E-7	0.001028	0.000311	-0.00054	0.000292	-7.16E-6	6.519E-6	0.000183	0.000102	-0.00159	-0.00568	-0.00643	0.005305	-4.58E-7	-0.00572	0.000424	0.01515

Row	Effect	Col1	Col2	Col3	Col4	Col5	Col6	Col7	Col8	Col9	Col10	Col11	Col12	Col13	Col14	Col15	Col16	Col17	Col18
81	melon	0.000645	-0.00009	-0.00410	0.000899	-0.00014	-0.00071	0.000017	0.000582	-0.00009	-0.00004	0.001414	0.000447	0.000366	-9.72E-6	-1.58E-6	0.006603	-0.00048	0.000148
82	melons	0.000028	0.000025	-0.00100	-0.00003	-0.00051	-0.00107	-0.00001	-0.00009	0.000298	-0.00003	0.000807	0.000012	0.000717	-0.00001	-2.62E-7	0.001388	0.000907	-0.00227
83	watermelon	-0.00149	0.000081	0.001899	0.000558	0.000417	0.000655	1.38E-6	0.000093	-0.00001	-0.00020	0.001290	0.004656	0.001976	0.001174	-3.76E-6	0.01351	0.01307	-0.00136
84	pear	0.001535	0.000011	0.000548	0.000526	-0.00014	-0.00064	-0.00002	-0.00029	-0.00007	0.000022	0.000303	-0.00283	-0.00018	0.000198	-9.62E-8	0.002995	0.004211	-0.00316
85	cherry	-0.00015	0.000029	-0.00054	-0.00057	2.132E-6	0.000120	-3.97E-6	-5.45E-7	-0.00009	0.000074	-0.00069	-0.00456	-0.00131	0.000131	-1.4E-7	0.001629	0.001638	-0.00075
86	apple	-0.00073	-0.00009	-0.00074	-0.00083	-0.00050	0.000583	-0.00005	0.000249	0.000257	-0.00017	0.005104	0.005336	0.002854	0.000354	1.01E-7	-0.00221	0.003550	-0.00366
87	peach	-0.00252	0.000259	0.002953	0.001155	-0.00120	-0.00020	0.000031	0.000393	-0.00021	0.000052	-0.00092	-0.00333	-0.00111	0.000515	-4.05E-7	0.003977	0.005545	-0.00254
88	nectarines	-0.00203	0.000090	0.001478	0.000335	-0.00097	0.000655	1.656E-6	0.000234	0.000147	0.000038	-0.00114	-0.00255	-0.00067	0.000165	-8.75E-8	0.001179	0.005574	-0.00109
89	grapes	0.000710	-0.00006	-0.00012	0.000255	-0.00016	-0.00002	9.171E-6	-0.00012	0.000034	-0.00004	0.000655	-0.00081	0.000734	0.000212	-7.88E-8	0.000463	0.002841	-0.00033
90	kiwi	-0.00013	0.000056	-0.00077	0.000884	-0.00050	-0.00006	-3.54E-6	0.000218	-6.87E-6	0.000134	-0.00094	-0.00219	-0.00190	-0.00033	4.645E-7	0.001667	-0.00498	-0.00182
91	orange	-0.00057	-9.25E-6	0.000416	-0.00132	0.000219	0.000208	-0.00002	0.000170	-0.00005	0.000136	0.000789	-0.00288	-0.00259	0.000304	5.465E-7	-0.00267	-0.00876	0.004185
92	persimmon	0.002941	-0.00017	0.000361	0.000089	-0.00047	-0.00007	-0.00002	0.000023	0.000018	0.000187	-0.00191	-0.01788	-0.00395	0.001744	-1.75E-7	-0.00159	0.007590	0.003557
93	mandarin	0.002835	-0.00003	0.000278	0.000498	0.000020	-0.00045	-0.00006	0.000652	-0.00027	0.000057	0.001314	-0.00544	-0.00146	0.000861	-4.51E-7	0.003682	-0.00190	0.000167
94	pomegranate	-0.00098	0.000148	0.000861	-0.00102	0.000302	-0.00015	-0.00003	3.333E-7	0.000152	0.000198	-0.00449	-0.00587	-0.00408	0.000971	4.124E-7	-0.00225	0.002236	0.005255
95	date	0.000346	-0.00004	0.000205	0.000380	-0.00047	0.001659	-0.00003	0.000144	0.000012	0.000087	0.001656	-0.01264	-0.00102	-0.00012	-5.81E-8	0.001776	0.01492	-0.00806
96	plums	0.002429	-0.00009	0.002833	0.000474	-0.00067	-0.00038	-0.00002	0.000056	-0.00008	0.000021	0.000287	-0.00473	-0.00038	3.399E-6	-2.32E-7	0.000514	0.006287	-0.00147
97	banana	-0.00545	0.000142	0.002285	-0.00217	0.000082	-4.8E-6	0.000081	0.000396	0.000165	0.000096	0.000800	-0.00331	-0.00109	0.000102	6.449E-7	0.000691	0.001584	-0.00636
98	sweetlemon	-0.00286	5.679E-6	0.001595	0.000646	-0.00043	0.000277	-0.00006	-0.00006	0.000225	-0.00002	0.000320	0.000479	0.000393	0.000182	1.428E-8	-0.00019	-0.00045	0.000167
99	lemon	0.001284	-0.00009	-0.00014	0.000065	-0.00002	-0.00146	-8.36E-6	0.000291	-0.00031	0.000133	-0.00055	-0.00447	-0.00234	0.000132	2.153E-7	-0.00020	0.000377	-0.00013
100	cantaloupjuic	-0.00183	0.000172	-0.00022	0.000307	0.000278	0.000159	-0.00002	0.000096	0.000136	0.000068	0.000038	-0.00179	-0.00157	0.000276	-7.83E-7	0.003420	-0.00224	0.000649
101	fruitjuicepackaging	-0.00094	0.000019	0.001198	-0.00236	0.000595	-0.00007	7.812E-6	0.000671	-0.00013	-0.00006	0.000434	-0.00099	0.000989	-0.00005	-1.19E-7	-0.00035	0.003612	0.002161
102	solidvegetableoil	-0.00096	0.000053	0.001898	-0.00157	-0.00076	-0.00140	-7.01E-6	-0.00006	0.000693	-0.00024	0.01151	0.01202	0.004289	-0.01031	-6.66E-7	-0.00383	-0.00262	0.01797
103	oil	-0.00203	3.993E-6	-0.00087	-0.00063	-0.00044	0.000714	0.000023	-0.00089	-0.00024	-0.00006	0.003477	0.002271	0.000736	-0.00421	-3.91E-7	-0.00097	0.001079	0.005813
104	mayonnais	-0.00298	0.000309	-0.00004	0.000543	0.000036	-0.00106	0.000060	-0.00053	0.000339	0.000035	0.000931	-0.00161	-0.00125	-0.00048	1.074E-7	-0.00199	-0.00326	0.005224
105	almonds	0.000301	-0.00005	0.000569	0.000356	0.000298	-5.17E-6	0.000060	0.000032	-0.00010	-0.00019	0.002661	0.01119	0.007155	-0.00870	2.472E-7	0.004728	-0.00158	-0.00984
106	walnut	-0.00269	-0.00013	-0.00165	-0.00173	-0.00018	0.000867	0.000037	0.000301	-0.00009	0.000165	0.000395	-0.00641	-0.00363	0.000919	1.503E-7	0.000494	0.002458	-0.00604
107	pistc	-0.00148	0.000026	0.000052	0.000347	0.000434	0.000437	0.000052	-0.00046	0.000119	-0.00022	0.003316	0.01114	0.007454	-0.00766	1.657E-7	0.004679	0.000718	-0.01172
108	seeds	-0.00119	0.000243	-0.00067	0.000389	0.000145	-0.00019	-0.00004	-0.00028	0.000131	-0.00040	0.009373	0.010000	0.01267	-0.00455	2.354E-8	0.01916	0.03423	-0.05913
109	sugar	0.000860	-0.00001	-0.00058	-0.00148	0.001703	-0.00112	0.000033	-0.00106	0.000086	-0.00001	0.000609	-0.01120	-0.00035	0.001186	-5.94E-7	0.000599	0.01338	0.000969
110	suger	-0.00055	-0.00008	0.001010	0.000396	0.000786	-0.00110	0.000070	-0.00040	-0.00022	-0.00002	0.001361	-0.00698	-0.00050	0.001043	-2.6E-7	-0.00083	0.006215	0.003904
111	honey	0.002294	-0.00028	0.000145	0.000470	-0.00064	-0.00016	0.000065	-0.00007	-0.00074	-0.00002	0.000153	0.003098	-0.00024	0.000314	5.012E-7	-0.00380	0.003662	0.002523
112	coladrink	0.000758	0.000085	0.001318	-0.00261	0.000836	-0.00038	-0.00010	0.000187	0.000160	-0.00003	-0.00062	0.001160	-0.00021	0.000571	6.272E-7	-0.00422	0.006531	0.005200
113	tea	0.000421	-0.00005	-0.00021	-0.00003	0.000191	-0.00030	-6.38E-6	-0.00011	-0.00005	0.000049	0.000851	-0.00173	-0.00052	-0.00027	1.269E-7	0.000725	-0.00422	-0.00236
114	chips	-0.00776	0.000419	0.000757	-0.00147	0.000266	0.000887	4.124E-6	0.000797	0.000414	-0.00015	0.003477	0.000497	0.002223	-0.00116	-1.7E-7	0.001236	0.002800	0.000884
115	coffee	0.000510	0.000098	0.000384	-0.00023	0.000365	-0.00053	-0.00007	0.000234	-0.00010	-1.15E-6	-0.00003	-0.00024	0.000307	-0.00043	6.726E-9	0.000523	0.000473	-0.00137
116	bakedmushroom	0.000245	0.000155	0.002554	0.000858	-0.00061	-0.00062	0.000024	-0.00084	-0.00013	-6.89E-6	-0.00017	0.001039	0.000257	-0.00022	-1.78E-7	0.001031	-0.00241	0.000647
117	salt	-0.00079	0.000021	0.000285	-0.00006	-0.00038	-0.00012	4.201E-6	3.207E-6	0.000035	-0.00001	0.000238	0.000207	0.000174	-0.00005	-2.28E-8	-0.00005	0.000175	0.000420

Fit Statistics	
-2 Res Log Likelihood	18354.1
AIC (smaller is better)	18356.1
AICC (smaller is better)	18356.1
BIC (smaller is better)	18354.1

PARMS Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
1	0.00	1.0000

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	-8.4052	0.5856	3425	-14.35	<.0001
age	0.1499	0.02270	3425	6.60	<.0001
cancer	0.7043	0.6299	3425	1.12	0.2636
hospital	0.6135	0.3476	3425	1.76	0.0777
sex	-0.7473	0.1132	3425	-6.60	<.0001
smok	0.2092	0.1814	3425	1.15	0.2487
bmi	0.1753	0.01133	3425	15.47	<.0001
marriag	0.2907	0.1398	3425	2.08	0.0377
edu	0.1258	0.06263	3425	2.01	0.0446

Solution for Fixed Effects					
Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
kcal10	0.002311	0.01253	3425	0.18	0.8538
protein50	-0.1206	0.3065	3425	-0.39	0.6941
cho100	-0.1589	0.5136	3425	-0.31	0.7571
fat20	-0.04148	0.2563	3425	-0.16	0.8714
msf10	-0.07623	0.1216	3425	-0.63	0.5306
carotenoids2	-0.00004	0.000041	3425	-1.07	0.2864
calcium1000	0.1336	0.2564	3425	0.52	0.6022
folate400	0.2055	0.4491	3425	0.46	0.6473
mg350	0.1832	0.4761	3425	0.38	0.7004
zinc10	-0.1410	0.1248	3425	-1.13	0.2586
fiber30	-0.04424	0.1530	3425	-0.29	0.7725
glucose20	-0.6844	0.4725	3425	-1.45	0.1476
fructose20	0.6120	0.3290	3425	1.86	0.0630

Solution for Random Effects					
Effect	Estimate	Std Err Pred	DF	t Value	Pr > |t|
lavash	0.03138	0.2176	3425	0.14	0.8853
barbari	-0.00482	0.1191	3425	-0.04	0.9677
sangak	0.02665	0.1776	3425	0.15	0.8808
taftun	-0.02395	0.1097	3425	-0.22	0.8271
budget	-0.1729	0.2891	3425	-0.60	0.5498
rice	0.05306	0.1210	3425	0.44	0.6611
pasta	0.1805	0.2267	3425	0.80	0.4261
potato	-0.1141	0.2529	3425	-0.45	0.6520
friedpo	0.04020	0.1479	3425	0.27	0.7858
soupnoodl	0.1818	0.2964	3425	0.61	0.5396
ashnoodl	-0.00701	0.2844	3425	-0.02	0.9803
biscuit	-0.06204	0.1313	3425	-0.47	0.6366
corn	0.03066	0.1552	3425	0.20	0.8434
barley	0.1211	0.2182	3425	0.56	0.5788
lentil	0.09420	0.1879	3425	0.50	0.6161
bean	0.05458	0.2564	3425	0.21	0.8314
pea	0.2247	0.2489	3425	0.90	0.3666
cookedbean	-0.03828	0.3338	3425	-0.11	0.9087
soybean	-0.2292	0.2525	3425	-0.91	0.3641
cotyledon	0.01611	0.2993	3425	0.05	0.9571
beef	-0.2626	0.2777	3425	-0.95	0.3445
lambmeat	0.3264	0.2344	3425	1.39	0.1638
groundbeef	-0.1254	0.2617	3425	-0.48	0.6318
chickens	0.2176	0.1836	3425	1.19	0.2361
fish	0.01772	0.1408	3425	0.13	0.8999
fishcanned	-0.02346	0.3108	3425	-0.08	0.9398
sausage	-0.1244	0.3335	3425	-0.37	0.7092
egg	-0.00044	0.001569	3425	-0.28	0.7811
pizza	-0.04203	0.2203	3425	-0.19	0.8487
lowfatmilk	0.001007	0.1169	3425	0.01	0.9931
wholmilk	-0.03266	0.1140	3425	-0.29	0.7745
chocolatmilk	0.09904	0.2003	3425	0.49	0.6211
yogurt	0.07468	0.1294	3425	0.58	0.5639
regularyogurt	-0.07241	0.1002	3425	-0.72	0.4698
fullfatyogurt	-0.1095	0.1214	3425	-0.90	0.3671
cheese	0.06168	0.08441	3425	0.73	0.4650
creamcheese	-0.1669	0.2663	3425	-0.63	0.5309
buttermilk	0.07702	0.1696	3425	0.45	0.6497
traditionalicream	0.04349	0.2478	3425	0.18	0.8607
butter	-0.07807	0.2203	3425	-0.35	0.7231
shreddedlettuce	-0.1766	0.2063	3425	-0.86	0.3918
tomato	-0.01251	0.1053	3425	-0.12	0.9054

Solution for Random Effects					
Effect	Estimate	Std Err Pred	DF	t Value	Pr > |t|
cucumber	0.04734	0.07397	3425	0.64	0.5222
eatingvegetabl	0.2112	0.2732	3425	0.77	0.4396
bakedeggplant	0.007587	0.3499	3425	0.02	0.9827
bakedcelery	-0.04778	0.3116	3425	-0.15	0.8782
greenpeascooked	-0.2026	0.3001	3425	-0.68	0.4997
greenbeanbaked	-0.01851	0.2173	3425	-0.09	0.9321
rawcarrots	0.01213	0.2121	3425	0.06	0.9544
bakedcarrots	0.04269	0.2732	3425	0.16	0.8758
rawonion	-0.06187	0.1591	3425	-0.39	0.6975
friedonion	0.05401	0.1889	3425	0.29	0.7750
cabbage	-0.08919	0.1254	3425	-0.71	0.4768
bellpeppers	0.05722	0.2291	3425	0.25	0.8028
cookedspinach	0.08744	0.2852	3425	0.31	0.7592
turnip	0.2109	0.3026	3425	0.70	0.4859
ketchup	-0.03291	0.2109	3425	-0.16	0.8760
torshi	0.03878	0.08694	3425	0.45	0.6556
melon	0.09721	0.1592	3425	0.61	0.5415
melons	0.003600	0.1886	3425	0.02	0.9848
watermelon	-0.01696	0.1422	3425	-0.12	0.9050
pear	0.04395	0.1875	3425	0.23	0.8147
cherry	-0.05443	0.07014	3425	-0.78	0.4378
apple	-0.1295	0.1154	3425	-1.12	0.2619
peach	0.05576	0.1866	3425	0.30	0.7651
nectarines	-0.1226	0.2831	3425	-0.43	0.6650
grapes	0.1269	0.05787	3425	2.19	0.0284
kiwi	-0.1663	0.2548	3425	-0.65	0.5140
orange	0.04658	0.1051	3425	0.44	0.6576
persimmon	0.09015	0.1559	3425	0.58	0.5630
mandarin	-0.1595	0.1513	3425	-1.05	0.2917
pomegranate	0.04383	0.1396	3425	0.31	0.7535
date	-0.00784	0.1888	3425	-0.04	0.9669
plums	-0.07155	0.2570	3425	-0.28	0.7807
banana	0.2789	0.1407	3425	1.98	0.0475
sweetlemon	-0.1265	0.1451	3425	-0.87	0.3834
lemon	-0.07375	0.1993	3425	-0.37	0.7113
cantaloupjuic	0.07692	0.1367	3425	0.56	0.5736
fruitjuicepackaging	0.1075	0.08773	3425	1.23	0.2204
solidvegetableoil	0.1230	0.2656	3425	0.46	0.6433
oil	-0.1905	0.2566	3425	-0.74	0.4579
mayonnais	0.2099	0.1995	3425	1.05	0.2928
almonds	0.07448	0.3075	3425	0.24	0.8087
walnut	0.04092	0.2068	3425	0.20	0.8432
pistc	0.02366	0.1775	3425	0.13	0.8940
seeds	0.2481	0.1946	3425	1.27	0.2024
sugar	-0.1711	0.2954	3425	-0.58	0.5623
suger	-0.2172	0.3203	3425	-0.68	0.4978
honey	0.01564	0.1944	3425	0.08	0.9359
coladrink	0.1675	0.1770	3425	0.95	0.3440
tea	-0.00626	0.02771	3425	-0.23	0.8214
chips	-0.2328	0.2735	3425	-0.85	0.3947
coffee	-0.03467	0.08415	3425	-0.41	0.6803
bakedmushroom	0.1011	0.1729	3425	0.58	0.5590
salt	0.01681	0.02267	3425	0.74	0.4586

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
age	1	3425	43.59	<.0001
cancer	1	3425	1.25	0.2636

Effect	Num DF	Den DF	F Value	Pr > F
hospital	1	3425	3.11	0.0777
sex	1	3425	43.57	<.0001
smok	1	3425	1.33	0.2487
bmi	1	3425	239.28	<.0001
marriag	1	3425	4.32	0.0377
edu	1	3425	4.04	0.0446
kcal10	1	3425	0.03	0.8538
protein50	1	3425	0.15	0.6941
cho100	1	3425	0.10	0.7571
fat20	1	3425	0.03	0.8714
msf10	1	3425	0.39	0.5306
carotenoids2	1	3425	1.14	0.2864
calcium1000	1	3425	0.27	0.6022
folate400	1	3425	0.21	0.6473
mg350	1	3425	0.15	0.7004
zinc10	1	3425	1.28	0.2586
fiber30	1	3425	0.08	0.7725
glucose20	1	3425	2.10	0.1476
fructose20	1	3425	3.46	0.0630

Type 3 Tests of Fixed Effects

GLIMMIX Model Statistics

Description	Value
Deviance	2712.9124
Scaled Deviance	2900.2080
Pearson Chi-Square	1.0668E13
Scaled Pearson Chi-Square	1.14045E13
Extra-Dispersion Scale	0.9354

The SAS System

The Mixed Procedure

Model Information	
Data Set	WORK._DS
Dependent Variable	_z
Weight Variable	_w
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Parameter
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Containment

Dimensions	
Covariance Parameters	1
Columns in X	22
Columns in Z	95
Subjects	1
Max Obs Per Subject	3616

Number of Observations	
Number of Observations Read	3616
Number of Observations Used	3542
Number of Observations Not Used	74

Parameter Search

CovP1	Res Log Like	-2 Res Log Like
0.9354	-9177.0443	18354.0886

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
1	1	18354.08857989	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate
Residual	0.9354

Row	Effect	Col1	Col2	Col3	Col4	Col5	Col6	Col7	Col8	Col9	Col10	Col11	Col12	Col13	Col14	Col15	Col16	Col17	Col18
1	Intercept	0.3429	-0.00602	0.004469	-0.00208	-0.00867	-0.04320	-0.00361	-0.02612	-0.02006	-0.00003	-0.00446	-0.00088	-0.00033	0.002136	6.634E-7	-0.00174	-0.01175	0.009079
2	age	-0.00602	0.000516	-0.00086	0.000068	0.000243	0.000087	0.000018	-0.00054	0.000467	-1.05E-6	0.000296	0.000146	0.000075	-0.00006	-2.85E-8	0.000350	0.000322	-0.00074
3	cancer	0.004469	-0.00086	0.3968	-0.00346	-0.00541	-0.00230	0.000131	0.002893	-0.00007	9.033E-6	0.000689	-0.00013	-0.00035	0.000183	-2.33E-7	-0.00320	-0.00058	0.001154
4	hospital	-0.00208	0.000068	-0.00346	0.1209	-0.00041	0.000670	0.000060	-0.00151	0.000218	-0.00007	0.001583	0.002675	0.001292	-0.00045	-1.11E-7	0.000730	0.001446	-0.00145
5	sex	-0.00867	0.000243	-0.00541	-0.00041	0.01282	0.004361	-0.00024	-0.00011	0.000371	0.000022	0.000416	0.000260	-0.00018	-0.00053	-5.16E-8	-0.00052	-3.9E-6	-0.00093
6	smok	-0.04320	0.000087	-0.00230	0.000670	0.004361	0.03289	0.000110	-0.00022	0.000755	-0.00003	-0.00166	0.000702	0.000481	-0.00020	-1.06E-7	-0.00126	0.001234	0.003540
7	bmi	-0.00361	0.000018	0.000131	0.000060	-0.00024	0.000110	0.000128	-0.00018	0.000080	-3.26E-6	0.000056	0.000157	0.000084	-0.00008	-6.09E-9	-0.00003	0.000066	-0.00001
8	marriag	-0.02612	-0.00054	0.002893	-0.00151	-0.00011	-0.00022	-0.00018	0.01956	0.000044	0.000043	-0.00006	-0.00216	-0.00101	0.000370	4.391E-8	-0.00051	0.000045	0.000686
9	edu	-0.02006	0.000467	-0.00007	0.000218	0.000371	0.000755	0.000080	0.000044	0.003922	-2.45E-6	0.000211	-0.00012	0.000097	-0.00009	-5.43E-8	0.000426	0.001175	-0.00089
10	kcal10	-0.00003	-1.05E-6	9.033E-6	-0.00007	0.000022	-0.00003	-3.26E-6	0.000043	-2.45E-6	0.000157	-0.00187	-0.00607	-0.00304	0.000408	4.844E-8	-0.00033	-0.00188	0.000917
11	protein50	-0.00446	0.000296	0.000689	0.001583	0.000416	-0.00166	0.000056	-0.00006	0.000211	-0.00187	0.09397	0.06827	0.03682	-0.00920	5.364E-7	0.006282	0.003549	-0.04876
12	cho100	-0.00088	0.000146	-0.00013	0.002675	0.000260	0.000702	0.000157	-0.00216	-0.00012	-0.00607	0.06827	0.2638	0.1185	-0.01872	-9.04E-7	0.01101	0.04694	-0.03988
13	fat20	-0.00033	0.000075	-0.00035	0.001292	-0.00018	0.000481	0.000084	-0.00101	0.000097	-0.00304	0.03682	0.1185	0.06568	-0.01569	-8.26E-8	0.01178	0.03373	-0.03715
14	msf10	0.002136	-0.00006	0.000183	-0.00045	-0.00053	-0.00020	-0.00008	0.000370	-0.00009	0.000408	-0.00920	-0.01872	-0.01569	0.01478	-4.94E-7	-0.00587	0.000586	0.01700
15	carotenoids2	6.634E-7	-2.85E-8	-2.33E-7	-1.11E-7	-5.16E-8	-1.06E-7	-6.09E-9	4.391E-8	-5.43E-8	4.844E-8	5.364E-7	-9.04E-7	-8.26E-8	-4.94E-7	1.698E-9	-5.69E-6	-3.69E-6	-2.09E-6
16	calcium1000	-0.00174	0.000350	-0.00320	0.000730	-0.00052	-0.00126	-0.00003	-0.00051	0.000426	-0.00033	0.006282	0.01101	0.01178	-0.00587	-5.69E-6	0.06572	0.01472	-0.05752
17	folate400	-0.01175	0.000322	-0.00058	0.001446	-3.9E-6	0.001234	0.000066	0.000045	0.001175	-0.00188	0.003549	0.04694	0.03373	0.000586	-3.69E-6	0.01472	0.2017	-0.06997
18	mg350	0.009079	-0.00074	0.001154	-0.00145	-0.00093	0.003540	-0.00001	0.000686	-0.00089	0.000917	-0.04876	-0.03988	-0.03715	0.01700	-2.09E-6	-0.05752	-0.06997	0.2267
19	zinc10	-0.00088	-0.00001	-0.00019	-0.00018	0.000178	0.000550	0.000017	-0.00016	0.000044	0.000078	-0.00556	-0.00245	-0.00094	-0.00093	-1.27E-8	-0.00493	-0.00425	-0.00597
20	fiber30	0.001372	-0.00014	0.000448	-0.00025	0.000482	0.000185	-5.68E-6	-5.12E-6	-0.00031	0.000502	-0.01180	-0.02077	-0.00862	0.000870	3.006E-7	-0.00838	-0.02194	-0.00178
21	glucose20	-0.00165	-0.00005	-0.00258	0.001179	-0.00017	0.001239	0.000071	-0.00040	0.000496	-0.00163	0.03804	0.03801	0.02914	0.000244	-2.45E-6	-0.00388	0.003080	-0.03394
22	fructose20	0.001286	-0.00005	0.000619	5.778E-6	0.000200	-0.00064	-0.00004	0.000260	-0.00008	0.001478	-0.03026	-0.05694	-0.02565	-0.00014	2.537E-7	0.01300	-0.00052	0.02361

Row	Effect	Col1	Col2	Col3	Col4	Col5	Col6	Col7	Col8	Col9	Col10	Col11	Col12	Col13	Col14	Col15	Col16	Col17	Col18
23	lavash	0.003067	-0.00015	0.000396	-0.00011	-0.00070	-0.00029	-0.00002	0.000423	0.000126	-0.00042	0.01122	0.009868	0.006726	0.000563	1.701E-6	-0.00494	-0.02484	0.03517
24	barbari	0.000482	0.000057	-0.00004	0.000277	-0.00014	-0.00034	-0.00002	-0.00003	0.000276	-0.00028	0.005344	0.003642	0.009631	-0.00316	7.485E-7	0.01205	0.01641	-0.03710
25	sangak	0.001348	0.000048	-0.00120	-0.00047	-0.00032	-0.00052	-0.00003	0.000031	0.000170	-0.00045	0.008445	0.006437	0.01520	-0.00488	1.186E-6	0.01790	0.02539	-0.05666
26	taftun	0.000252	0.000035	0.000616	-0.00009	-0.00022	-0.00074	-0.00001	-0.00007	0.000232	-0.00026	0.005311	0.003641	0.008774	-0.00278	7.343E-7	0.01018	0.01410	-0.03206
27	budget	0.000171	0.000149	0.000195	0.000935	-8.98E-6	-0.00063	-0.00005	0.000274	0.000021	0.000113	-0.00310	-0.00643	-0.00118	-0.00045	5.51E-7	-0.00189	-0.02443	0.01107
28	rice	-0.00017	0.000018	0.000010	0.000132	-0.00004	0.000483	2.725E-6	-0.00009	-0.00024	0.000105	0.001656	-0.01241	-0.00092	-0.00008	5.467E-7	0.000094	-0.03099	0.01127
29	pasta	-0.00502	0.000249	0.000911	0.000663	0.000451	0.000997	0.000034	-0.00013	-0.00022	-0.00003	0.000030	-0.00141	0.001426	-0.00074	2.951E-7	-0.00010	-0.01156	0.002606
30	potato	-0.00106	-0.00027	0.002736	0.000688	0.000030	0.000280	0.000072	0.000054	0.000277	-0.00008	0.001598	-0.00081	0.002588	-0.00075	1.535E-7	0.002163	0.000172	-0.00485
31	friedpo	-0.00029	0.000101	0.000241	0.000192	-0.00001	0.000312	-0.00001	-0.00014	-0.00002	-0.00007	0.001530	0.000326	0.001386	-0.00038	-5.57E-8	0.001151	0.004005	-0.00121
32	soupnoodl	0.001262	-0.00018	0.000641	0.000277	0.000788	0.000886	0.000035	-0.00049	-0.00019	0.000079	-0.00070	-0.00512	-0.00061	-0.00054	-5.71E-8	0.001669	-0.01410	0.003156
33	ashnoodl	-0.00009	-0.00011	0.000814	-0.00023	-0.00014	0.001075	0.000023	-0.00006	0.000015	0.000014	-0.00151	-0.00307	0.000769	-0.00030	3.475E-8	0.000812	-0.01647	0.002892
34	biscuit	0.000697	0.000087	-0.00015	0.001599	-0.00067	-0.00036	-0.00004	0.000561	-0.00027	-0.00011	0.000644	0.001172	0.002744	-0.00085	3.6E-7	-0.00054	0.007710	-0.00475
35	corn	-0.00025	0.000072	0.001012	0.000382	-0.00019	-0.00023	-1.6E-6	-0.00042	0.000029	4.617E-6	0.000161	-0.00002	-0.00026	0.000340	9.585E-8	-0.00022	0.000163	0.000346
36	barley	0.000710	-0.00015	0.001279	-0.00074	-0.00039	0.000688	0.000015	0.000036	0.000016	-0.00007	0.000429	0.001030	0.001901	-0.00051	-1.69E-7	0.002543	-0.00456	-0.00028
37	lentil	0.000252	-0.00007	-0.00181	-0.00026	-0.00083	0.000267	0.000023	0.000074	-0.00016	0.000240	-0.00183	-0.00540	-0.00313	-0.00073	7.04E-7	0.002094	-0.04246	0.01134
38	bean	-0.00328	-0.00011	-0.00021	-0.00140	0.000592	0.001328	0.000041	0.000179	-0.00020	0.000026	0.000765	-0.00085	0.000939	-0.00136	4.71E-7	0.000638	-0.01467	-0.00024
39	pea	0.002455	-0.00012	0.000459	0.001802	-0.00011	-0.00085	-0.00002	0.000103	-0.00014	0.000104	0.000213	-0.00128	-0.00057	-0.00080	5.224E-7	0.002206	-0.03085	0.004053
40	cookedbean	-0.00065	-0.00001	-0.00046	0.000121	0.000101	0.000366	0.000014	-0.00009	-0.00002	0.000012	-0.00003	-0.00011	0.000283	-0.00053	1.44E-8	0.001370	-0.00830	0.001274
41	soybean	0.002983	-0.00013	-0.00127	-0.00018	-0.00031	0.000339	-0.00003	0.000344	-0.00016	4.693E-6	-0.00929	0.005082	0.001802	-0.00109	6.155E-7	0.005946	-0.02624	-0.00085
42	cotyledon	-0.00163	-0.00006	-0.00076	0.000049	0.000724	-0.00014	0.000026	-0.00029	0.000056	-0.00007	-0.00012	0.002663	0.002371	-0.00122	1.956E-7	0.002274	-0.00725	-0.00116
43	beef	0.004291	-0.00002	-0.00185	0.000480	0.000224	-0.00109	-0.00006	0.000514	-0.00066	-0.00034	-0.00585	0.01382	0.006990	-0.00106	-1.86E-7	0.001194	0.007220	0.003190
44	lambmeat	-0.00048	0.000145	-0.00006	0.001420	-0.00047	0.000870	0.000038	-0.00070	-0.00020	-0.00044	-0.00625	0.01748	0.008736	-0.00141	-2.52E-7	0.001675	0.008881	0.003260
45	groundbeef	0.001322	-0.00003	0.002130	-0.00049	-0.00123	-0.00015	0.000094	-0.00123	-0.00057	-0.00030	-0.00858	0.01217	0.006168	-0.00220	-3.45E-7	0.000993	0.005541	0.005705
46	chickens	0.001997	-0.00015	0.000379	-0.00036	-0.00013	0.000914	-0.00002	-0.00015	-0.00005	-0.00092	-0.02437	0.03653	0.01837	-0.00179	-8.99E-7	0.004159	0.02529	0.004300
47	fish	0.001588	-0.00006	-0.00037	0.000148	-0.00021	0.000678	0.000016	-0.00054	-0.00003	-0.00075	-0.01860	0.03294	0.01589	-0.00215	-3.16E-7	0.004225	0.01704	-0.00379
48	fishcanned	-0.00393	0.000122	0.001446	0.000303	0.000286	0.000185	1.443E-6	0.000530	0.000439	-0.00022	-0.00461	0.009076	0.004602	-0.00028	1.541E-7	0.000419	0.003105	-0.00136
49	sausage	-0.00260	0.000145	-0.00006	-0.00006	0.000067	-0.00009	-6.32E-7	0.000524	-0.00005	-0.00013	-0.00061	0.004890	0.002812	-0.00141	-2.77E-8	0.000388	0.000898	0.001534
50	egg	-0.00004	2.897E-6	-0.00009	-7.97E-7	0.000013	7.758E-7	-7.9E-7	7.857E-6	-7.24E-7	-2.59E-6	-0.00006	0.000118	0.000048	-0.00001	-1.79E-9	-5.86E-6	-0.00004	0.000095
51	pizza	-0.00148	0.000248	-0.00216	0.000232	-5.05E-6	0.000571	-0.00005	0.000042	-0.00023	-0.00028	-0.00860	0.008394	0.005733	-0.00167	3.539E-7	-0.00391	-0.00142	0.01264
52	lowfatmilk	-0.00058	-0.00014	0.001906	0.000119	-0.00027	0.000560	-2.69E-6	0.000289	0.000047	-0.00015	-0.00617	0.005159	0.002475	0.000753	1.366E-6	-0.01320	0.003599	0.008090
53	wholmilk	-0.00173	-0.00006	-0.00021	0.000321	-0.00043	0.000207	0.000025	0.000096	0.000053	-0.00015	-0.00484	0.003807	0.001201	0.001357	1.101E-6	-0.01364	0.004772	0.01263
54	chocolatmilk	-0.00302	0.000174	-0.00209	0.001357	0.000192	0.000051	0.000016	0.000593	-0.00016	-0.00013	-0.00156	-0.00005	0.002954	0.000046	1.291E-6	-0.00684	0.01125	-0.00658
55	yogurt	0.001875	-0.00005	-0.00115	-0.00037	0.000103	0.000595	-0.00004	0.000399	0.000193	-0.00019	-0.00864	0.001889	0.001378	0.003002	-5.45E-7	-0.00155	0.01051	0.01174
56	regularyogurt	0.000488	-0.00012	0.000128	0.000580	0.000121	0.000735	-7.47E-6	0.000087	-0.00010	-0.00016	-0.00574	0.004994	0.002331	0.000583	1.579E-6	-0.01583	0.000561	0.01185
57	fullfatyogurt	0.000797	-0.00002	0.001307	0.000666	0.000174	-0.00014	-1.16E-6	-0.00059	-0.00001	-0.00035	-0.00161	0.01132	0.005050	0.000564	1.121E-6	-0.01428	0.009583	0.009007
58	cheese	-0.00069	-0.00007	0.000917	-0.00033	-0.00008	0.000061	-4.91E-6	0.000081	-0.00005	-0.00004	-0.00365	0.002497	-0.00086	0.001501	5.542E-7	-0.00910	-0.00244	0.01377
59	creamcheese	0.002143	-0.00007	-0.00176	-0.00074	0.000645	0.000820	-0.00001	0.000089	-0.00015	-0.00001	-0.00105	0.000675	-0.00100	-0.00023	-2.1E-7	-0.00272	-0.00103	0.009508
60	buttermilk	0.000226	-0.00007	0.002431	-0.00085	0.000293	0.000603	7.374E-6	-0.00038	8.822E-6	-0.00020	-0.00637	0.006531	0.002803	0.001052	1.768E-6	-0.01706	0.001757	0.01382
61	traditionalicream	0.000679	-0.00011	0.000972	0.000929	0.000979	0.000663	-0.00002	0.000240	-0.00009	-0.00016	0.000936	0.001827	0.001429	-0.00009	1.9E-8	-0.00553	0.005650	0.009903
62	butter	-0.00376	0.000045	-0.00054	0.001830	0.000732	-0.00028	0.000113	0.000377	-0.00009	0.000013	0.002390	-0.00157	-0.00439	0.000403	-8.26E-7	-0.00592	-0.00078	0.01993
63	shreddedlettuce	0.000265	-0.00006	0.002806	0.001717	0.000746	0.000719	-0.00005	0.000520	-0.00031	0.000083	-0.00096	-0.00046	-0.00126	-0.00012	-1.25E-7	-0.00042	-0.01622	0.005770
64	tomato	0.000528	-0.00005	-0.00237	-0.00050	-0.00015	0.000015	-0.00003	-0.00027	0.000045	-0.00006	-0.00054	0.002646	-0.00007	0.000494	-2.92E-6	0.01106	0.003437	0.001601
65	cucumber	0.000655	0.000019	0.001570	-0.00106	-0.00048	0.000112	-0.00003	0.000122	-0.00004	0.000013	0.000617	0.000188	0.000270	-0.00035	5.371E-8	0.001931	-0.00054	-0.00445
66	eatingvegetabl	-0.00310	-0.00043	0.003023	-0.00008	-0.00059	0.000925	-2.94E-6	0.001063	0.000811	0.000056	-0.00224	-0.00177	-0.00055	-0.00061	-5.41E-7	-0.00058	-0.00056	-0.00016
67	bakedeggplant	-0.00020	-2.21E-6	0.000012	-0.00002	-7.05E-6	0.000022	2.7E-6	6.888E-6	0.000023	-2.14E-6	9.321E-6	-0.00005	0.000021	0.000023	-2.64E-8	0.000040	0.000122	-0.00003
68	bakedcelery	0.000790	-0.00019	0.000073	0.000570	-0.00017	0.000217	-0.00003	0.000753	-0.00006	0.000017	-0.00002	-0.00052	-0.00031	0.000325	-4.68E-7	0.001659	-0.00286	-0.00048
69	greenpeascooked	0.002945	-0.00009	0.002231	0.001310	-0.00022	-0.00037	-0.00005	-0.00010	0.000053	0.000030	0.000618	-0.00019	-0.00065	0.000279	-5.34E-7	0.004141	-0.00804	-0.00063
70	greenbeanbaked	0.000230	-0.00014	0.000287	-0.00132	-0.00067	-0.00017	2.326E-6	-0.00008	0.000177	-0.00008	0.002543	0.003754	0.001572	-0.00014	-3.68E-7	0.002248	-0.00208	-0.00444
71	rawcarrots	0.001367	0.000107	0.002281	-0.00111	-0.00062	0.000163	-0.00005	-0.00017	0.000043	-0.00003	-0.00210	-0.00114	-0.00137	0.001332	-4.58E-6	0.01463	0.005142	0.006291
72	bakedcarrots	0.000390	-0.00010	0.000158	0.000437	-0.00047	0.000512	-0.00001	-0.00023	0.000088	-0.00007	-0.00275	-0.00069	-0.00069	0.001311	-4.83E-6	0.01579	0.007318	0.007364
73	rawonion	0.004305	-0.00024	-0.00029	-0.00213	0.000768	-0.00005	-0.00010	0.000122	-0.00024	0.000016	-0.00088	0.000258	-0.00015	-0.00018	2.99E-8	0.000600	-0.00309	0.001616
74	friedonion	0.002483	0.000065	0.001403	-0.00039	-0.00370	-0.00053	0.000048	-0.00085	0.000215	0.000078	-0.00078	-0.00516	-0.00126	-0.00155	-1.03E-7	-0.00078	-0.00826	0.006920
75	cabbage	-0.00195	-0.00001	-0.00062	-0.00144	-0.00007	-0.00018	-0.00003	-0.00035	0.000241	-0.00001	0.000336	0.000582	0.000292	-0.00009	7.539E-8	-0.00041	0.000245	0.000509
76	bellpeppers	0.002122	-0.00006	0.002687	0.001861	-0.00139	0.000204	0.000017	-0.00003	0.000104	-0.00004	-0.00055	0.003309	0.000248	-0.00021	-9.26E-7	0.005575	-0.00508	0.000137
77	cookedspinach	0.002002	-0.00012	-0.00049	0.000558	-0.00028	-0.00037	-0.00002	-0.00003	0.000026	-0.00001	-0.00036	0.000880	-0.00033	0.000490	-2.66E-6	0.01060	-0.00443	0.000325
78	turnip	0.000423	-8.12E-6	0.001232	0.001180	-0.00033	-0.00006	0.000010	0.000154	-0.00009	0.000075	0.000852	-0.00335	-0.00149	0.000336	1.924E-7	-0.00083	-0.00019	-0.00025
79	ketchup	-0.00319	0.000292	-0.00491	0.001547	0.000904	0.000697	8.896E-7	0.000313	-0.00046	-0.00008	-0.00118	0.001801	0.000544	0.000294	-1.91E-6	0.006304	0.002361	0.004992
80	torshi	-0.00006	-2.53E-7	0.001028	0.000311	-0.00054	0.000292	-7.16E-6	6.519E-6	0.000183	0.000102	-0.00159	-0.00568	-0.00643	0.005305	-4.58E-7	-0.00572	0.000424	0.01515

Row	Effect	Col1	Col2	Col3	Col4	Col5	Col6	Col7	Col8	Col9	Col10	Col11	Col12	Col13	Col14	Col15	Col16	Col17	Col18
81	melon	0.000645	-0.00009	-0.00410	0.000899	-0.00014	-0.00071	0.000017	0.000582	-0.00009	-0.00004	0.001414	0.000447	0.000366	-9.72E-6	-1.58E-6	0.006603	-0.00048	0.000148
82	melons	0.000028	0.000025	-0.00100	-0.00003	-0.00051	-0.00107	-0.00001	-0.00009	0.000298	-0.00003	0.000807	0.000012	0.000717	-0.00001	-2.62E-7	0.001388	0.000907	-0.00227
83	watermelon	-0.00149	0.000081	0.001899	0.000558	0.000417	0.000655	1.38E-6	0.000093	-0.00001	-0.00020	0.001290	0.004656	0.001976	0.001174	-3.76E-6	0.01351	0.01307	-0.00136
84	pear	0.001535	0.000011	0.000548	0.000526	-0.00014	-0.00064	-0.00002	-0.00029	-0.00007	0.000022	0.000303	-0.00283	-0.00018	0.000198	-9.62E-8	0.002995	0.004211	-0.00316
85	cherry	-0.00015	0.000029	-0.00054	-0.00057	2.132E-6	0.000120	-3.97E-6	-5.45E-7	-0.00009	0.000074	-0.00069	-0.00456	-0.00131	0.000131	-1.4E-7	0.001629	0.001638	-0.00075
86	apple	-0.00073	-0.00009	-0.00074	-0.00083	-0.00050	0.000583	-0.00005	0.000249	0.000257	-0.00017	0.005104	0.005336	0.002854	0.000354	1.01E-7	-0.00221	0.003550	-0.00366
87	peach	-0.00252	0.000259	0.002953	0.001155	-0.00120	-0.00020	0.000031	0.000393	-0.00021	0.000052	-0.00092	-0.00333	-0.00111	0.000515	-4.05E-7	0.003977	0.005545	-0.00254
88	nectarines	-0.00203	0.000090	0.001478	0.000335	-0.00097	0.000655	1.656E-6	0.000234	0.000147	0.000038	-0.00114	-0.00255	-0.00067	0.000165	-8.75E-8	0.001179	0.005574	-0.00109
89	grapes	0.000710	-0.00006	-0.00012	0.000255	-0.00016	-0.00002	9.171E-6	-0.00012	0.000034	-0.00004	0.000655	-0.00081	0.000734	0.000212	-7.88E-8	0.000463	0.002841	-0.00033
90	kiwi	-0.00013	0.000056	-0.00077	0.000884	-0.00050	-0.00006	-3.54E-6	0.000218	-6.87E-6	0.000134	-0.00094	-0.00219	-0.00190	-0.00033	4.645E-7	0.001667	-0.00498	-0.00182
91	orange	-0.00057	-9.25E-6	0.000416	-0.00132	0.000219	0.000208	-0.00002	0.000170	-0.00005	0.000136	0.000789	-0.00288	-0.00259	0.000304	5.465E-7	-0.00267	-0.00876	0.004185
92	persimmon	0.002941	-0.00017	0.000361	0.000089	-0.00047	-0.00007	-0.00002	0.000023	0.000018	0.000187	-0.00191	-0.01788	-0.00395	0.001744	-1.75E-7	-0.00159	0.007590	0.003557
93	mandarin	0.002835	-0.00003	0.000278	0.000498	0.000020	-0.00045	-0.00006	0.000652	-0.00027	0.000057	0.001314	-0.00544	-0.00146	0.000861	-4.51E-7	0.003682	-0.00190	0.000167
94	pomegranate	-0.00098	0.000148	0.000861	-0.00102	0.000302	-0.00015	-0.00003	3.333E-7	0.000152	0.000198	-0.00449	-0.00587	-0.00408	0.000971	4.124E-7	-0.00225	0.002236	0.005255
95	date	0.000346	-0.00004	0.000205	0.000380	-0.00047	0.001659	-0.00003	0.000144	0.000012	0.000087	0.001656	-0.01264	-0.00102	-0.00012	-5.81E-8	0.001776	0.01492	-0.00806
96	plums	0.002429	-0.00009	0.002833	0.000474	-0.00067	-0.00038	-0.00002	0.000056	-0.00008	0.000021	0.000287	-0.00473	-0.00038	3.399E-6	-2.32E-7	0.000514	0.006287	-0.00147
97	banana	-0.00545	0.000142	0.002285	-0.00217	0.000082	-4.8E-6	0.000081	0.000396	0.000165	0.000096	0.000800	-0.00331	-0.00109	0.000102	6.449E-7	0.000691	0.001584	-0.00636
98	sweetlemon	-0.00286	5.679E-6	0.001595	0.000646	-0.00043	0.000277	-0.00006	-0.00006	0.000225	-0.00002	0.000320	0.000479	0.000393	0.000182	1.428E-8	-0.00019	-0.00045	0.000167
99	lemon	0.001284	-0.00009	-0.00014	0.000065	-0.00002	-0.00146	-8.36E-6	0.000291	-0.00031	0.000133	-0.00055	-0.00447	-0.00234	0.000132	2.153E-7	-0.00020	0.000377	-0.00013
100	cantaloupjuic	-0.00183	0.000172	-0.00022	0.000307	0.000278	0.000159	-0.00002	0.000096	0.000136	0.000068	0.000038	-0.00179	-0.00157	0.000276	-7.83E-7	0.003420	-0.00224	0.000649
101	fruitjuicepackaging	-0.00094	0.000019	0.001198	-0.00236	0.000595	-0.00007	7.812E-6	0.000671	-0.00013	-0.00006	0.000434	-0.00099	0.000989	-0.00005	-1.19E-7	-0.00035	0.003612	0.002161
102	solidvegetableoil	-0.00096	0.000053	0.001898	-0.00157	-0.00076	-0.00140	-7.01E-6	-0.00006	0.000693	-0.00024	0.01151	0.01202	0.004289	-0.01031	-6.66E-7	-0.00383	-0.00262	0.01797
103	oil	-0.00203	3.993E-6	-0.00087	-0.00063	-0.00044	0.000714	0.000023	-0.00089	-0.00024	-0.00006	0.003477	0.002271	0.000736	-0.00421	-3.91E-7	-0.00097	0.001079	0.005813
104	mayonnais	-0.00298	0.000309	-0.00004	0.000543	0.000036	-0.00106	0.000060	-0.00053	0.000339	0.000035	0.000931	-0.00161	-0.00125	-0.00048	1.074E-7	-0.00199	-0.00326	0.005224
105	almonds	0.000301	-0.00005	0.000569	0.000356	0.000298	-5.17E-6	0.000060	0.000032	-0.00010	-0.00019	0.002661	0.01119	0.007155	-0.00870	2.472E-7	0.004728	-0.00158	-0.00984
106	walnut	-0.00269	-0.00013	-0.00165	-0.00173	-0.00018	0.000867	0.000037	0.000301	-0.00009	0.000165	0.000395	-0.00641	-0.00363	0.000919	1.503E-7	0.000494	0.002458	-0.00604
107	pistc	-0.00148	0.000026	0.000052	0.000347	0.000434	0.000437	0.000052	-0.00046	0.000119	-0.00022	0.003316	0.01114	0.007454	-0.00766	1.657E-7	0.004679	0.000718	-0.01172
108	seeds	-0.00119	0.000243	-0.00067	0.000389	0.000145	-0.00019	-0.00004	-0.00028	0.000131	-0.00040	0.009373	0.010000	0.01267	-0.00455	2.354E-8	0.01916	0.03423	-0.05913
109	sugar	0.000860	-0.00001	-0.00058	-0.00148	0.001703	-0.00112	0.000033	-0.00106	0.000086	-0.00001	0.000609	-0.01120	-0.00035	0.001186	-5.94E-7	0.000599	0.01338	0.000969
110	suger	-0.00055	-0.00008	0.001010	0.000396	0.000786	-0.00110	0.000070	-0.00040	-0.00022	-0.00002	0.001361	-0.00698	-0.00050	0.001043	-2.6E-7	-0.00083	0.006215	0.003904
111	honey	0.002294	-0.00028	0.000145	0.000470	-0.00064	-0.00016	0.000065	-0.00007	-0.00074	-0.00002	0.000153	0.003098	-0.00024	0.000314	5.012E-7	-0.00380	0.003662	0.002523
112	coladrink	0.000758	0.000085	0.001318	-0.00261	0.000836	-0.00038	-0.00010	0.000187	0.000160	-0.00003	-0.00062	0.001160	-0.00021	0.000571	6.272E-7	-0.00422	0.006531	0.005200
113	tea	0.000421	-0.00005	-0.00021	-0.00003	0.000191	-0.00030	-6.38E-6	-0.00011	-0.00005	0.000049	0.000851	-0.00173	-0.00052	-0.00027	1.269E-7	0.000725	-0.00422	-0.00236
114	chips	-0.00776	0.000419	0.000757	-0.00147	0.000266	0.000887	4.124E-6	0.000797	0.000414	-0.00015	0.003477	0.000497	0.002223	-0.00116	-1.7E-7	0.001236	0.002800	0.000884
115	coffee	0.000510	0.000098	0.000384	-0.00023	0.000365	-0.00053	-0.00007	0.000234	-0.00010	-1.15E-6	-0.00003	-0.00024	0.000307	-0.00043	6.726E-9	0.000523	0.000473	-0.00137
116	bakedmushroom	0.000245	0.000155	0.002554	0.000858	-0.00061	-0.00062	0.000024	-0.00084	-0.00013	-6.89E-6	-0.00017	0.001039	0.000257	-0.00022	-1.78E-7	0.001031	-0.00241	0.000647
117	salt	-0.00079	0.000021	0.000285	-0.00006	-0.00038	-0.00012	4.201E-6	3.207E-6	0.000035	-0.00001	0.000238	0.000207	0.000174	-0.00005	-2.28E-8	-0.00005	0.000175	0.000420

Fit Statistics	
-2 Res Log Likelihood	18354.1
AIC (smaller is better)	18356.1
AICC (smaller is better)	18356.1
BIC (smaller is better)	18354.1

PARMS Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
1	0.00	1.0000

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	-8.4052	0.5856	3425	-14.35	<.0001
age	0.1499	0.02270	3425	6.60	<.0001
cancer	0.7043	0.6299	3425	1.12	0.2636
hospital	0.6135	0.3476	3425	1.76	0.0777
sex	-0.7473	0.1132	3425	-6.60	<.0001
smok	0.2092	0.1814	3425	1.15	0.2487
bmi	0.1753	0.01133	3425	15.47	<.0001
marriag	0.2907	0.1398	3425	2.08	0.0377
edu	0.1258	0.06263	3425	2.01	0.0446

Solution for Fixed Effects					
Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
kcal10	0.002311	0.01253	3425	0.18	0.8538
protein50	-0.1206	0.3065	3425	-0.39	0.6941
cho100	-0.1589	0.5136	3425	-0.31	0.7571
fat20	-0.04148	0.2563	3425	-0.16	0.8714
msf10	-0.07623	0.1216	3425	-0.63	0.5306
carotenoids2	-0.00004	0.000041	3425	-1.07	0.2864
calcium1000	0.1336	0.2564	3425	0.52	0.6022
folate400	0.2055	0.4491	3425	0.46	0.6473
mg350	0.1832	0.4761	3425	0.38	0.7004
zinc10	-0.1410	0.1248	3425	-1.13	0.2586
fiber30	-0.04424	0.1530	3425	-0.29	0.7725
glucose20	-0.6844	0.4725	3425	-1.45	0.1476
fructose20	0.6120	0.3290	3425	1.86	0.0630

Solution for Random Effects					
Effect	Estimate	Std Err Pred	DF	t Value	Pr > |t|
lavash	0.03138	0.2176	3425	0.14	0.8853
barbari	-0.00482	0.1191	3425	-0.04	0.9677
sangak	0.02665	0.1776	3425	0.15	0.8808
taftun	-0.02395	0.1097	3425	-0.22	0.8271
budget	-0.1729	0.2891	3425	-0.60	0.5498
rice	0.05306	0.1210	3425	0.44	0.6611
pasta	0.1805	0.2267	3425	0.80	0.4261
potato	-0.1141	0.2529	3425	-0.45	0.6520
friedpo	0.04020	0.1479	3425	0.27	0.7858
soupnoodl	0.1818	0.2964	3425	0.61	0.5396
ashnoodl	-0.00701	0.2844	3425	-0.02	0.9803
biscuit	-0.06204	0.1313	3425	-0.47	0.6366
corn	0.03066	0.1552	3425	0.20	0.8434
barley	0.1211	0.2182	3425	0.56	0.5788
lentil	0.09420	0.1879	3425	0.50	0.6161
bean	0.05458	0.2564	3425	0.21	0.8314
pea	0.2247	0.2489	3425	0.90	0.3666
cookedbean	-0.03828	0.3338	3425	-0.11	0.9087
soybean	-0.2292	0.2525	3425	-0.91	0.3641
cotyledon	0.01611	0.2993	3425	0.05	0.9571
beef	-0.2626	0.2777	3425	-0.95	0.3445
lambmeat	0.3264	0.2344	3425	1.39	0.1638
groundbeef	-0.1254	0.2617	3425	-0.48	0.6318
chickens	0.2176	0.1836	3425	1.19	0.2361
fish	0.01772	0.1408	3425	0.13	0.8999
fishcanned	-0.02346	0.3108	3425	-0.08	0.9398
sausage	-0.1244	0.3335	3425	-0.37	0.7092
egg	-0.00044	0.001569	3425	-0.28	0.7811
pizza	-0.04203	0.2203	3425	-0.19	0.8487
lowfatmilk	0.001007	0.1169	3425	0.01	0.9931
wholmilk	-0.03266	0.1140	3425	-0.29	0.7745
chocolatmilk	0.09904	0.2003	3425	0.49	0.6211
yogurt	0.07468	0.1294	3425	0.58	0.5639
regularyogurt	-0.07241	0.1002	3425	-0.72	0.4698
fullfatyogurt	-0.1095	0.1214	3425	-0.90	0.3671
cheese	0.06168	0.08441	3425	0.73	0.4650
creamcheese	-0.1669	0.2663	3425	-0.63	0.5309
buttermilk	0.07702	0.1696	3425	0.45	0.6497
traditionalicream	0.04349	0.2478	3425	0.18	0.8607
butter	-0.07807	0.2203	3425	-0.35	0.7231
shreddedlettuce	-0.1766	0.2063	3425	-0.86	0.3918
tomato	-0.01251	0.1053	3425	-0.12	0.9054

Solution for Random Effects					
Effect	Estimate	Std Err Pred	DF	t Value	Pr > |t|
cucumber	0.04734	0.07397	3425	0.64	0.5222
eatingvegetabl	0.2112	0.2732	3425	0.77	0.4396
bakedeggplant	0.007587	0.3499	3425	0.02	0.9827
bakedcelery	-0.04778	0.3116	3425	-0.15	0.8782
greenpeascooked	-0.2026	0.3001	3425	-0.68	0.4997
greenbeanbaked	-0.01851	0.2173	3425	-0.09	0.9321
rawcarrots	0.01213	0.2121	3425	0.06	0.9544
bakedcarrots	0.04269	0.2732	3425	0.16	0.8758
rawonion	-0.06187	0.1591	3425	-0.39	0.6975
friedonion	0.05401	0.1889	3425	0.29	0.7750
cabbage	-0.08919	0.1254	3425	-0.71	0.4768
bellpeppers	0.05722	0.2291	3425	0.25	0.8028
cookedspinach	0.08744	0.2852	3425	0.31	0.7592
turnip	0.2109	0.3026	3425	0.70	0.4859
ketchup	-0.03291	0.2109	3425	-0.16	0.8760
torshi	0.03878	0.08694	3425	0.45	0.6556
melon	0.09721	0.1592	3425	0.61	0.5415
melons	0.003600	0.1886	3425	0.02	0.9848
watermelon	-0.01696	0.1422	3425	-0.12	0.9050
pear	0.04395	0.1875	3425	0.23	0.8147
cherry	-0.05443	0.07014	3425	-0.78	0.4378
apple	-0.1295	0.1154	3425	-1.12	0.2619
peach	0.05576	0.1866	3425	0.30	0.7651
nectarines	-0.1226	0.2831	3425	-0.43	0.6650
grapes	0.1269	0.05787	3425	2.19	0.0284
kiwi	-0.1663	0.2548	3425	-0.65	0.5140
orange	0.04658	0.1051	3425	0.44	0.6576
persimmon	0.09015	0.1559	3425	0.58	0.5630
mandarin	-0.1595	0.1513	3425	-1.05	0.2917
pomegranate	0.04383	0.1396	3425	0.31	0.7535
date	-0.00784	0.1888	3425	-0.04	0.9669
plums	-0.07155	0.2570	3425	-0.28	0.7807
banana	0.2789	0.1407	3425	1.98	0.0475
sweetlemon	-0.1265	0.1451	3425	-0.87	0.3834
lemon	-0.07375	0.1993	3425	-0.37	0.7113
cantaloupjuic	0.07692	0.1367	3425	0.56	0.5736
fruitjuicepackaging	0.1075	0.08773	3425	1.23	0.2204
solidvegetableoil	0.1230	0.2656	3425	0.46	0.6433
oil	-0.1905	0.2566	3425	-0.74	0.4579
mayonnais	0.2099	0.1995	3425	1.05	0.2928
almonds	0.07448	0.3075	3425	0.24	0.8087
walnut	0.04092	0.2068	3425	0.20	0.8432
pistc	0.02366	0.1775	3425	0.13	0.8940
seeds	0.2481	0.1946	3425	1.27	0.2024
sugar	-0.1711	0.2954	3425	-0.58	0.5623
suger	-0.2172	0.3203	3425	-0.68	0.4978
honey	0.01564	0.1944	3425	0.08	0.9359
coladrink	0.1675	0.1770	3425	0.95	0.3440
tea	-0.00626	0.02771	3425	-0.23	0.8214
chips	-0.2328	0.2735	3425	-0.85	0.3947
coffee	-0.03467	0.08415	3425	-0.41	0.6803
bakedmushroom	0.1011	0.1729	3425	0.58	0.5590
salt	0.01681	0.02267	3425	0.74	0.4586

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
age	1	3425	43.59	<.0001
cancer	1	3425	1.25	0.2636

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
hospital	1	3425	3.11	0.0777
sex	1	3425	43.57	<.0001
smok	1	3425	1.33	0.2487
bmi	1	3425	239.28	<.0001
marriag	1	3425	4.32	0.0377
edu	1	3425	4.04	0.0446
kcal10	1	3425	0.03	0.8538
protein50	1	3425	0.15	0.6941
cho100	1	3425	0.10	0.7571
fat20	1	3425	0.03	0.8714
msf10	1	3425	0.39	0.5306
carotenoids2	1	3425	1.14	0.2864
calcium1000	1	3425	0.27	0.6022
folate400	1	3425	0.21	0.6473
mg350	1	3425	0.15	0.7004
zinc10	1	3425	1.28	0.2586
fiber30	1	3425	0.08	0.7725
glucose20	1	3425	2.10	0.1476
fructose20	1	3425	3.46	0.0630

GLIMMIX Model Statistics

Description	Value
Deviance	2712.9124
Scaled Deviance	2900.2080
Pearson Chi-Square	1.0668E13
Scaled Pearson Chi-Square	1.14045E13
Extra-Dispersion Scale	0.9354

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1 & 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1 & 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	3
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	Not applicable
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3 & 4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4 & 5
Bias	9	Describe any efforts to address potential sources of bias	5 & 6
Study size	10	Explain how the study size was arrived at	3
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were	4

		chosen and why	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5 & 6
		(*b*) Describe any methods used to examine subgroups and interactions	5 & 6
		(*c*) Explain how missing data were addressed	5 & 6
		(*d*) If applicable, explain how loss to follow-up was addressed	5 & 6
		(*e*) Describe any sensitivity analyses	5 & 6
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	14
		(b) Give reasons for non-participation at each stage	20
		(c) Consider use of a flow diagram	20
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	14
		(b) Indicate number of participants with missing data for each variable of interest	14
		(c) Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	Report numbers of outcome events or summary measures over time	20, 6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	16-19
		(*b*) Report category boundaries when continuous variables were categorized	16-19
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	16-19
Discussion			
Key results	18	Summarise key results with reference to study objectives	7
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	9
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	7-9
Generalisability	21	Discuss the generalisability (external validity) of the study results	10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	10