

Citation:

Wang J, Luben R, Khaw KT, Bingham S, Wareham NJ, Forouhi NG. Dietary energy density predicts the risk of incident type 2 diabetes: the European Prospective Investigation of Cancer (EPIC)-Norfolk Study. *Diabetes Care*. 2008 Nov; 31 (11): 2,120-2,125. Epub 2008 Aug 8.

PubMed ID: [18689693](#)

Study Design:

Prospective Cohort Study

Class:

B - [Click here](#) for explanation of classification scheme.

Research Design and Implementation Rating:

NEUTRAL: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

To investigate the association of dietary energy density with new-onset diabetes in a population-based cohort study including both men and women, appropriately adjusted for a comprehensive range of lifestyle factors, social factors and dietary factors.

Inclusion Criteria:

EPIC-Norfolk Cohort Study participants.

Exclusion Criteria:

- Participants with diagnosed prevalent diabetes, cancer or cardiovascular disease at baseline since they may have altered their diet as a result of their condition
- Participants with a missing food-frequency questionnaire (FFQ) or with >10 missing dietary items
- Participants in the top 0.5% and bottom 0.5% of the ratio of self-reported energy intake to basal metabolic rate.

Description of Study Protocol:**Recruitment**

- The European Prospective Investigation of Cancer (EPIC) Norfolk Cohort Study was a population-based prospective study of individuals aged 40 to 79 years at baseline
- A total of 25,639 volunteers were recruited from general practices in Norwich and surrounding towns in Norfolk between 1993 and 1997.

Design

Prospective cohort study.

Dietary Intake/Dietary Assessment Methodology

Energy density for overall diet calculated from FFQs.

Blinding Used

Not applicable.

Intervention

Not applicable.

Statistical Analysis

- Differences between men and women in baseline characteristics and dietary energy density were tested using T-tests for continuous variables and by chi-square tests for categorical variables
- Dietary energy density was defined as both a continuous variable and categorically by quintiles
- Associations between dietary energy density and risk of developing type 2 diabetes were examined through three logistic regression models
- Sensitivity analyses were completed to identify plausible under-reporters of dietary intake.

Data Collection Summary:

Timing of Measurements

- Median 10.2 years (range 7.6 to 12.8 years) of follow-up
- Participants completed a baseline health check between 1993 and 1997 and follow-up constituted a postal questionnaire at 18 months, a second health check in 1998 to 2000 and a further postal questionnaire in 2002 to 2004
- Information on diet was collected at baseline.

Dependent Variables

- New-onset cases of diabetes based on self-report of doctor-diagnosed diabetes from the second health check or follow-up health and lifestyle questionnaires, self-report of diabetes-specific medication in either of the two follow-up questionnaires or medication brought to the follow-up health check
- External sources of information through record linkage included listing of any EPIC-Norfolk participant in the general practice diabetes register, local hospital diabetes register, hospital admissions data at that hospital screened for any diabetes-related admissions among study participants and Office of National Statistics mortality data with coding for diabetes
- Participants who gave a self-report of history of diabetes that could not be confirmed with any other sources of ascertainment were not included as confirmed cases of diabetes.

Independent Variables

Energy density calculated for overall diet using 130-item validated EPIC FFQs with nine possible frequency responses.

Control Variables

- Age
- Sex
- Baseline BMI
- Family history of diabetes
- Physical activity
- Smoking
- Occupational status
- Education
- Alcohol consumption
- Total energy intake
- Percentage of energy from dietary fat
- Baseline waist circumference
- Weight change
- Menopausal status
- Use of hormone replacement therapy (HRT).

Description of Actual Data Sample:

- *Initial N*: 25,639 participants in the cohort
- *Attrition (final N)*: 21,919 participants (9,781 men and 12,138 women) after exclusion criteria applied
- *Age*: 40 to 79 years at baseline
- *Ethnicity*: 99.1% European-Caucasian origin
- *Other relevant demographics*: None listed
- *Anthropometrics*: None listed
- *Location*: United Kingdom.

Summary of Results:

Association Between Dietary Energy Density and Risk of Type 2 Diabetes: EPIC-Norfolk Study

Variables	DED	DED Quintile 1	DED Quintile 2	DED Quintile 3	DED Quintile 4	DED Quintile 5	P for trend
Dietary energy density (kJ per gram)	1.04-7.97	1.04-2.43	2.43-2.78	2.78-3.12	3.12-3.55	3.55-7.97	---
Men	1.30-7.53	1.30-2.55	2.55-2.92	2.92-3.26	3.26-3.70	3.70-7.53	---
Women	1.04-7.97	1.04-2.35	2.35-2.67	2.67-3.00	3.00-3.42	3.42-7.97	---
Incident Cases	725	135	140	138	143	169	---
Model 1	1.12 (1.01-0.25), P=0.032	1.00	1.07 (0.83-0.37)	1.05 (0.82-1.35)	1.11 (0.87-1.43)	1.34 (1.05-1.70)	0.022

Model 2	1.13 (1.01-1.26), P=0.028	1.00	1.04 (0.80-1.34)	1.06 (0.82-1.36)	1.10 (0.86-1.42)	1.35 (1.06-1.73)	0.016
Model 3	1.20 (1.05-1.37), P=0.007	1.00	1.10 (0.85-1.42)	1.15 (0.88-1.49)	1.23 (0.93-1.61)	1.58 (1.18-2.12)	0.003

Other Findings

- During median 10.2 years (range 7.6 to 12.8 years) of follow-up, 725 new-onset cases of type 2 diabetes were documented among 21,919 participants
- Baseline energy density was higher in those who developed type 2 diabetes (mean 3.08kJ per gram [95% CI: 3.03 to 3.13] than in those who remained non-diabetic (3.01kJ per gram [95% CI: 3.00 to 3.02], P=0.012)
- Case participants were less physically active (inactive 42.2 vs. 28.4% and active 16.0 vs. 19.1%, P<0.001), more obese (BMI 29.7 vs. 26.2kg/m², waist circumference 99.4 vs. 87.5 cm, and obesity prevalence 40.4 vs. 13.8%, all P<0.001) and more likely to have a positive family history of diabetes than those who did not develop diabetes
- Energy density was positively associated with incident diabetes (odds ratio 1.21 per unit increase [95% CI 1.06 to 1.38]) adjusted for known risk factors
- There was a 60% higher risk of diabetes (1.60 [1.19 to 2.16]) in the highest quintile of energy density (range 3.55 to 7.97kJ per gram) compared with the lowest quintile (1.04 to 2.43kJ per gram) in adjusted analyses
- There was no significant interaction between dietary energy density and either BMI or waist circumference or between dietary energy density and sex on the risk of diabetes
- Compared with the highest dietary energy density quintile, participants in the lowest group consumed significantly more fresh fruit, more vegetables, less meat, less processed meat, less soft drinks, more alcoholic drinks, more non-energy containing beverages and a lower percentage of energy from fat.

Author Conclusion:

In summary, we have shown prospectively that higher dietary energy density at baseline predicts the risk of incident diabetes independently of baseline BMI, total energy intake and other known risk factors. This finding has potential implications for preventing type 2 diabetes through adoption of a healthier lifestyle and merits further research, including confirmation in other studies.

Reviewer Comments:

- *Large sample size and 12 years of follow-up*
- *Dietary data collected only at baseline*
- *Authors note the following limitations:*
 - *Dietary intake assessed by semi-quantitative FFQ with its own associated limitations*
 - *Only ascertained diagnosed incident cases of diabetes; undiagnosed cases may be present*
 - *Population predominantly European-Caucasian and cannot be considered valid in other groups.*

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions

- | | | |
|----|---|-----|
| 1. | Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies) | Yes |
| 2. | Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about? | Yes |
| 3. | Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice? | Yes |
| 4. | Is the intervention or procedure feasible? (NA for some epidemiological studies) | Yes |

Validity Questions

- | | | |
|------|---|-----|
| 1. | Was the research question clearly stated? | Yes |
| 1.1. | Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified? | Yes |
| 1.2. | Was (were) the outcome(s) [dependent variable(s)] clearly indicated? | Yes |
| 1.3. | Were the target population and setting specified? | Yes |
| 2. | Was the selection of study subjects/patients free from bias? | Yes |
| 2.1. | Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study? | Yes |
| 2.2. | Were criteria applied equally to all study groups? | Yes |
| 2.3. | Were health, demographics, and other characteristics of subjects described? | Yes |
| 2.4. | Were the subjects/patients a representative sample of the relevant population? | Yes |
| 3. | Were study groups comparable? | Yes |
| 3.1. | Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT) | N/A |
| 3.2. | Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline? | N/A |
| 3.3. | Were concurrent controls used? (Concurrent preferred over historical controls.) | N/A |

3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	Yes
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	N/A
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	Was method of handling withdrawals described?	Yes
4.1.	Were follow-up methods described and the same for all groups?	Yes
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	Yes
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	Yes
4.4.	Were reasons for withdrawals similar across groups?	N/A
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	Was blinding used to prevent introduction of bias?	Yes
5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	N/A
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	Yes
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	Yes
5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were intervening factors described?	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	N/A
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	Yes

6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	N/A
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	N/A
6.6.	Were extra or unplanned treatments described?	N/A
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	N/A
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	Were outcomes clearly defined and the measurements valid and reliable?	Yes
7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes
7.5.	Was the measurement of effect at an appropriate level of precision?	Yes
7.6.	Were other factors accounted for (measured) that could affect outcomes?	Yes
7.7.	Were the measurements conducted consistently across groups?	N/A
8.	Was the statistical analysis appropriate for the study design and type of outcome indicators?	Yes
8.1.	Were statistical analyses adequately described and the results reported appropriately?	Yes
8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	N/A
8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	Yes
8.6.	Was clinical significance as well as statistical significance reported?	Yes

8.7.	If negative findings, was a power calculation reported to address type 2 error?	N/A
9.	Are conclusions supported by results with biases and limitations taken into consideration?	Yes
9.1.	Is there a discussion of findings?	Yes
9.2.	Are biases and study limitations identified and discussed?	Yes
10.	Is bias due to study's funding or sponsorship unlikely?	Yes
10.1.	Were sources of funding and investigators' affiliations described?	Yes
10.2.	Was the study free from apparent conflict of interest?	Yes