Nutrition and mortality in the elderly over 10 years of follow-up: the Three-City study

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Abstract
In the last 20 years, many prospective cohort studies have assessed the relationships between food consumption and mortality. Result interpretation is mainly hindered by the limited adjustment for confounders and, to a lesser extent, the small sample sizes. The aim of this study was to investigate the association between dietary habits and all-cause mortality in a multicentre prospective cohort that included non-institutionalised, community-based elderly individuals (Three-City Study). A brief FFQ was administered at baseline. Hazard ratios (HR) and 95% CI for all-cause mortality were estimated relative to the consumption frequency of several food groups, using Cox proportional hazards models adjusted for sex, centre, socio-demographic characteristics and health status indicators. Among the 8937 participants (mean age: 74 ± 2 years, 60.7% women), 2016 deaths were recorded during an average follow-up of 9 years. The risk of death was significantly lower among subjects with the highest fruit and vegetable consumption (HR 0.90; 95% CI 0.82–0.99, P = 0.03) and with regular fish consumption (HR 0.89; 95% CI 0.81–0.97, P = 0.01). The benefit of olive oil use was found only in women (moderate olive oil use: HR 0.80; 95% CI 0.68–0.94, P = 0.007; intensive use: HR 0.72; 95% CI 0.60–0.85, P = 0.0002). Conversely, daily meat consumption increased the mortality risk (HR 1.12; 95% CI, 1.01–1.24, P = 0.03). No association was found between risk of death and diet diversity and use of various fats. These findings suggest that fruits/vegetables, olive oil and regular fish consumptions have a beneficial effect on the risk of death, independently of the socio-demographic features and the number of medical conditions.

Key words: Mortality; Dietary habits; Fruits and vegetables; Olive oil; Regular fish consumption

The number of elderly people is progressively increasing. Besides medical progress, the life expectancy increase could also be linked to environmental and behavioural factors, some of which can be modified to achieve beneficial effects for health, particularly dietary habits1. The importance of diet has led public health policymakers to develop specific prevention programmes. Moreover, large observational studies have examined the relationship between diet and all-cause mortality in elderly subjects using various food habit classifications that focus, for example, on specific foods or food consumption groups or on dietary patterns that combine multiple features. The results show that some dietary patterns (eating habits, including several food groups), such as the Mediterranean diet2–13 or ‘healthy’ dietary groups defined by high consumption of fruits, vegetables and fish14–17 or greater consumption of olive oil with raw vegetables18, have a protective effect. Similarly, some studies on consumption frequency found that high intakes of fruits and/or vegetables19–21, fish20,22 or coffee23–25 have a beneficial effect on survival. However, a few of these studies have considered the most relevant adjustment factors. Indeed, dietary habits and mortality are both influenced by many factors not only at the individual level (age, sex, health status, socio-economic, cultural and genetic factors) but also at the population level (for instance, food availability and accessibility in terms of cost).

Another way to assess the effect of diet on health is to consider the concept of food diversity. The advantage of studying the diversity of diets and of used fats compared with monotonous diets is that it allows evaluating the consumption of the most essential micronutrients and of different types of fatty acids (FA). This concept is a part of the French National Health and Nutrition Programme20. Indeed, a varied diet, defined by the daily consumption of at least 1 unit of each

Abbreviations: 3C, Three-City; DDS, diet diversity score; HR, hazard ratio.
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essential food group, has been associated with a lower mortality risk\textsuperscript{27,28}. However, a few studies have focused on this approach.

Therefore, our main objective was to examine the associations between dietary habits and mortality in an elderly population. The data collected by the 10-year follow-up study of the large French population-based Three-City (3C) cohort allowed investigating whether some dietary habits (consumption of fruits, vegetables, olive oil, fish and caffeine, diet diversity and diversity of used fats) are associated with reduced all-cause mortality in people aged >65 years, independently of previously identified major confounders.

Methods

Data were extracted from the database of the 3C study, a prospective cohort study of vascular risk factors of dementia\textsuperscript{29}. The present study was conducted according to the Declaration of Helsinki guidelines. The 3C study protocol was approved by the Consultative Committee for the Protection of Persons participating in Biomedical Research of the Kremlin-Bicêtre University Hospital (Paris, France). All participants signed a written informed consent.

Participants

A sample of community dwellers aged 65 years and older was selected in 1999/2000 from the electoral rolls of Bordeaux (South-West of France), Montpellier (South-East of France) and Dijon (North-East of France). To be eligible for recruitment into the study\textsuperscript{29}, persons had to be (1) living in these cities or their suburbs and registered on the electoral rolls, (2) aged 65 years and older and (3) not institutionalised. The cohort size by centre was set at 2500 in Bordeaux, 5000 in Dijon and 2500 in Montpellier. A personal letter was sent to each potential subject inviting them to participate, including a brief description of the study protocol and an acceptance/refusal form. The spouse/partner was also invited to participate in the study if he/she met eligibility criteria. As electoral rolls are occasionally inaccurate (persons who have moved may still be registered at their previous address), no further correspondence was sent to persons who did not respond to the first letter, but an attempt was made to contact them by telephone. In total, 24 % of the eligible persons selected from the electoral rolls (n = 34 922) could not be reached; among those contacted, the acceptance rate was 37 %. A total of 9693 persons were included; seven persons aged <65 years were subsequently excluded. Participants who had subsequently refused to participate in the baseline medical interview (n = 392) were excluded from all analyses leading to an original sample of 9294 community dwellers.

The participants were administered standardised questionnaires and underwent clinical examinations at baseline and after 2, 4, 8 and 10 years. Baseline data were collected by standardised face-to-face interviews. They included information on socio-demographic features, lifestyle (including a brief FFQ), current symptoms and complaints, medical history, blood pressure, past and present consumption of tobacco, alcohol and drug use, anthropometric data, neuropsychological testing and blood sampling.

For the present study, the following participants were excluded: 132 (1.4 %) subjects with missing data for at least one dietary variable, 214 (2.3 %) people with a diagnosis of dementia at baseline and eleven (0.12 %) individuals with no available vital statistics data. The analysis was thus carried out using a sample of 8937 participants with a mean follow-up of 8.85 years.

Baseline dietary assessment

The brief FFQ was administered at baseline to assess the participants’ dietary habits concerning nine broad food categories: (1) meat and poultry, (2) fish (including seafood), (3) eggs, (4) milk and dairy products, (5) cereals (including bread and starches), (6) raw fruits, (7) raw vegetables, (8) cooked fruits or vegetables and (9) pulses. Consumption frequency was classified as follows: never, <1 time/week, 1 time/week, 2–3 times/week, 4–6 times/week and daily. The dietary habits of the whole sample have been described previously\textsuperscript{30}. Participants were also invited to indicate the dietary fats used at least 1 time/week for dressing, cooking or spreading among those included in the following list: butter, margarine, maize oil, peanut oil, sunflower or grapeseed oil, olive oil, blended oil, duck or goose fat, lard, ‘Vegetaline’\textsuperscript{31} (mainly SFA), colza oil, walnut oil and soyabean oil. Caffeine consumption was calculated by multiplying the number of cups of tea and/or coffee consumed per day by their estimated caffeine content (about 50 mg/cup for tea and 100 mg/cup for coffee\textsuperscript{31}).

Fruits/vegetables, fish, meat and olive oil were the four main food consumption groups of interest that were studied as categorical variables. Their consumption thresholds were based on the French National Nutrition and Health Programme guidelines, when applicable to the available data\textsuperscript{26}. Cooked fruits and vegetables, olive oil and caffeine consumptions were investigated using previously defined categories\textsuperscript{31–33}. Dietary habits included the intake of fish/seafood (<2 times/week v. ≥2 times/week), fruits and vegetables (<1 fruit and 1 vegetable, cooked or raw/d v. at least 1 fruit and 1 vegetable, cooked or raw/d, and <4–6 servings of cooked fruits or vegetables/week v. ≥4–6 servings of cooked fruits or vegetables/week), meat (<1 time/d v. >1 time/d), caffeine (<250, 250–375, >375 mg/d). Further, three categories of olive oil consumption were defined: ‘no use’, ‘moderate use’ (for cooking or dressing alone) or ‘intensive use’ (for cooking and for dressing)\textsuperscript{33,34}. To calculate the diet diversity score (DDS) (from 0 to 5), one point was assigned for each of the following food categories consumed at least once per day: dairy products, meat, cereals, fruits and vegetables. Low diversity was defined by a DDS <3 and high diversity by a DDS ≥4\textsuperscript{35}. Fat diversity was evaluated as ≤3 different fats v. >3 fats. The threshold of the three different fats corresponds to the median value of various fats used by the population included in the 3C cohort.

Baseline covariates

Socio-demographic information recorded at baseline included age, sex, centre, educational level (no or primary/middle/high
school/university), occupation (white collar, employee, blue collar, housewife) and monthly income level (<1500, >1500 euros). Health behaviours were assessed on the basis of smoking status (no, 0–10, 10–30 or >30 packets/year) and intake of alcholic beverages (0–24, >24 g/d for women; 0–36, >36 g/d for men).

Blood pressure and anthropometric data were measured in standardised conditions. Health-related variables included BMI (<27 and ≥27 kg/m²), hypertension (defined as a systolic blood pressure >140 mmHg or diastolic blood pressure >90 mmHg or use of antihypertensive drugs) (37), diabetes (fasting blood glucose ≥7.0 mmol/l or use of anti-diabetic drugs), hypercholesterolaemia (yes/no, self-reported) and the number of drugs used (0, 1–4, ≥5). History of CVD (yes/no) and other chronic diseases (chronic respiratory disease, cancer, Parkinson’s disease or hypothyroidism) was reported. Disability was estimated using the instrumental activities of daily living scale (yes [score >0]/no). Depressive mood was assessed using the Center for Epidemiological Studies-Depression scale and was defined by a score <17 for men and <<23 for women. Self-rated health was grouped into three categories (poor, average, fair) and self-assessment of correct diet into two classes (no/yes).

Physical activity was assessed differently in the three centres (self-reported or not and with different accuracy levels). Therefore, a common binary variable was considered for the three centres (none, low or regular). Regular physical activity was defined as taking part in some sport regularly or having at least 1 h of leisure or household activity/d (38). Given the important amount of missing data for this variable (1115 missing data for the Bordeaux centre, 11 % of the whole sample), it was used only in sensitivity analyses.

Vital status
Mortality was ascertained from the civil registry by systematic request for all subjects not included in follow-up visits. The date of death was defined as the date of the event, and the date of the last follow-up or phone contact for the 10-year follow-up was considered as the date of censoring. Follow-up included the precise assessment of all causes of death that were coded according to the tenth revision of the International Classification of Diseases (ICD-10) (39). Mortality from CVD (ICD-10: I) and cancer (ICD-10: C), the two leading causes of death in aged populations, were considered for the analyses (39).

Statistical analyses
Survival analysis was carried out using the Kaplan–Meier method. Comparisons of baseline characteristics and dietary habits were performed using the log-rank test.

The associations between dietary habits, diet diversity and mortality risk were determined using Cox proportional hazards regression with delayed entry, with age (in years) used as the time axis and left truncation at the age of study entry. The results of the survival analysis are expressed as hazard ratios (HR) with 95 % CI.

In these analyses, the adjustments for covariates were performed in three steps. Univariate analysis was the basic model to test associations between dietary features and mortality (crude model). The second model (model 1) was adjusted for sex, study centre, educational level, occupation and income. Health behaviours and health factors, chosen on the basis of literature data, were then added to the third model (model 2). Interactions between the different dietary habits and covariates included in model 2 were tested and stratified analyses were carried out accordingly.

For missing data, multiple imputations were generated by generating five copies of the original data set in which the missing values for the covariates considered in the analysis were replaced by values generated according to the Markov Chain Monte Carlo method and using the PROC MI procedure. Each imputed data set was analysed as if it were complete to calculate the mean HR and CI with the PROC MIANALYZE procedure (40). Imputations were performed for covariates included in the analyses: education (missing data 0-17 %), income (6-13 %), occupation (0-29 %), smoking (1-63 %), alcohol intake (1-51 %), history of CVD (0-08 %), depression (1-28 %), diabetes (5-65 %), hypertension (0-06 %), hypercholesterolaemia (1-1 %), dependence (0-09 %), self-rated health (0-57 %), number of chronic diseases (0-09 %) and self-rated diet quality (2-38 %).

Analyses were carried out using SAS software (version 9.2).

Results
The baseline characteristics and dietary habits of the participants (n = 8937) according to their vital status (dead/alive) at the end of the 10-year follow-up are reported in Tables 1 and 2, respectively. Participants who died (n = 2016) were significantly older at baseline than those still alive (mean age: 77 v. 73 years, respectively) and more often men, heavy smokers or alcohol consumers. They also had more often a history of CVD or chronic diseases, more vascular risk factors and poor self-rated health. In these crude comparisons, mortality risk was higher among individuals with low income and blue-collar workers. Conversely, survival was not influenced by the educational level in this highly educated population. Daily consumption of fruits and vegetables, regular consumption of cooked vegetables/fruits, intensive olive oil use, wide fat diversity and bi-weekly fish consumption were more frequently reported by subjects still alive at the end of the 10-year follow-up. Caffeine consumption and DDS were not associated with survival.

Next, the associations between the 10-year mortality risk and dietary habits or diet diversity (at baseline) were assessed after multiple imputations for missing data (Tables 3 and 4, respectively). In crude analyses, various well-known healthy food habits were significantly associated with better survival: eating at least 1 fruit and 1 vegetable (raw or cooked)/d, consumption of at least 4 cooked fruit/vegetable servings/week, consumption of at least 2 servings/week of fish, meat <1 serving/d, greater diet diversity and diversity in fat use.

In the partly (only socio-demographic covariates) and fully (socio-demographic and health-related covariates) adjusted models, consuming at least 1 fruit and vegetable/d and consuming >4 cooked fruit/vegetable servings/week remained significantly associated with a better survival compared with lower levels of consumption (HR 0-90; 95 % CI 0-82, 0-99, 0-81).
Table 1. Baseline socio-demographic and medical characteristics of the Three-City cohort (n 8937) subdivided according to their vital status (dead or alive) at the end of the 10-year follow-up (Numbers and percentages; mean value and standard deviation)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Alive (n 6921) (77%)</th>
<th>Dead (n 2016) (23%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td>n %</td>
<td>n %</td>
</tr>
<tr>
<td>Mean SD</td>
<td>73 4.9 6.1</td>
<td>77</td>
</tr>
<tr>
<td>Women</td>
<td>4507 65 4941 47</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No or primary</td>
<td>1747 25 531 26</td>
<td></td>
</tr>
<tr>
<td>Secondary</td>
<td>2474 36 714 36</td>
<td></td>
</tr>
<tr>
<td>High school</td>
<td>1403 20 389 19</td>
<td></td>
</tr>
<tr>
<td>University</td>
<td>1287 19 377 19</td>
<td></td>
</tr>
<tr>
<td>Monthly income higher than 1500‡</td>
<td>4148 64 1153 62</td>
<td></td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White collar</td>
<td>2790 40 815 41</td>
<td></td>
</tr>
<tr>
<td>Employee</td>
<td>2029 29 536 27</td>
<td></td>
</tr>
<tr>
<td>Blue collar</td>
<td>1395 20 496 25</td>
<td></td>
</tr>
<tr>
<td>Housewife</td>
<td>687 10 164 8</td>
<td></td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>4436 65 1047 53</td>
<td></td>
</tr>
<tr>
<td>0–10 packets/year</td>
<td>902 13 274 14</td>
<td></td>
</tr>
<tr>
<td>10–29 packets/year</td>
<td>893 9 287 15</td>
<td></td>
</tr>
<tr>
<td>&gt;30 packets/year</td>
<td>586 9 340 17</td>
<td></td>
</tr>
<tr>
<td>Alcohol intake ≥24 g/d for women;</td>
<td>643 9 237 12</td>
<td></td>
</tr>
<tr>
<td>≥36 g/d for men</td>
<td></td>
<td></td>
</tr>
<tr>
<td>History of CVD*</td>
<td>1752 25 878 44</td>
<td></td>
</tr>
<tr>
<td>BMI &lt;27 kg/m²</td>
<td>4688 68 1280 65</td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>679 13 333 17</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>588 9 287 15</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>5235 76 1684 84</td>
<td></td>
</tr>
<tr>
<td>Hypercholesterolaemia</td>
<td>2405 35 553 28</td>
<td></td>
</tr>
<tr>
<td>Dependence†</td>
<td>431 6 398 20</td>
<td></td>
</tr>
<tr>
<td>Low/regular physical activity</td>
<td>2119 34 373 22</td>
<td></td>
</tr>
<tr>
<td>Self-rated health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>276 4 182 9</td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td>2337 34 828 41</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>4275 62 988 49</td>
<td></td>
</tr>
<tr>
<td>Number of drugs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>651 9 103 5</td>
<td></td>
</tr>
<tr>
<td>1–4</td>
<td>3433 50 752 37</td>
<td></td>
</tr>
<tr>
<td>≥5</td>
<td>2837 41 1161 58</td>
<td></td>
</tr>
<tr>
<td>Number of chronic diseases‡</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>5850 85 1567 78</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>975 14 396 20</td>
<td></td>
</tr>
<tr>
<td>≥2</td>
<td>91 1 50 2</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Baseline food habits of the Three-City cohort (n 8937) subdivided according to their vital status (alive or dead) at the end of the 10-year follow-up (Numbers and percentages)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Alive (n 6921) (77%)</th>
<th>Dead (n 2016) (23%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>At least 1 fruit and 1 vegetable, cooked or raw/d</strong></td>
<td>2782 40 663 33</td>
<td></td>
</tr>
<tr>
<td>Cooked fruits/vegetables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥4–6 servings/week</td>
<td>6162 89 1715 85</td>
<td></td>
</tr>
<tr>
<td>Meat ≥1 serving/d</td>
<td>1689 24 558 28</td>
<td></td>
</tr>
<tr>
<td>Fish ≥2 servings/week</td>
<td>3569 52 923 46</td>
<td></td>
</tr>
<tr>
<td>Diversity diet score ≥4</td>
<td>4986 72 1371 68</td>
<td></td>
</tr>
<tr>
<td>Olive oil use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1543 23 644 32</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>2768 40 755 37</td>
<td></td>
</tr>
<tr>
<td>Intensive</td>
<td>2610 38 617 31</td>
<td></td>
</tr>
<tr>
<td>Different fats &gt;3</td>
<td>1523 22 345 17</td>
<td></td>
</tr>
<tr>
<td>Caffeine (mg/d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤250</td>
<td>4781 69 1489 74</td>
<td></td>
</tr>
<tr>
<td>250–375</td>
<td>1441 21 370 18</td>
<td></td>
</tr>
<tr>
<td>&gt;375</td>
<td>699 10 157 8</td>
<td></td>
</tr>
<tr>
<td>Self-rated diet quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bad</td>
<td>589 9 171 9</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>6174 91 1790 91</td>
<td></td>
</tr>
</tbody>
</table>

Finally, there was no significant association between dietary habits/diversity and the main causes of death (389 due to CVD and 542 due to cancer) after controlling for sex, centre, educational level, income and occupation (data not shown).

**Discussion**

The present study based on the 10-year follow-up of a French cohort of people aged 65 years or older suggests that healthy dietary habits such as daily consumption of fruits and vegetables, eating 2 servings/week of fish and regular use of olive oil (only in women) are significantly linked to better survival, independently of socio-demographic, health-related and lifestyle variables. Overall, higher diet diversity is associated with lower mortality risk.
A major difficulty when assessing food habits concerns the heterogeneity of the collected data. Indeed, each country has its consumption standards, tailored to cultural habits and the local availability of food resources. Moreover, the methods used to collect such data are also not homogeneous, and consequently results are difficult to compare and generalise from one country to another. Nevertheless, the various eating habits can be standardised in dietary patterns (such as composite scores or consumption patterns of some preferred foods) or by quantitative measurements of food types. Studies on diet quality or adherence to a particular diet are used to determine the most beneficial approach; however, in the case of composite scores, the proper role of each score component cannot be identified. In the present study, where food habits were evaluated with a short FFQ, we examined food groups that have been found to be associated by their fibre content that modulates LDL-cholesterol level, insulin sensitivity and blood pressure(43), all conditions associated with increased mortality risk. This hypothesis is supported by the PREDIMED (Prevention con dieta Mediterranea) study that demonstrated a significant association between lower risk of death and baseline higher fibre intake and fruit consumption(44).

Our results are in agreement with the few studies that have investigated fish consumption and risk of death(20,22). A Japanese study found that high consumption of vegetables and fish in subjects older than 75 years is associated with longer lifespan in previous studies using these different approaches. Our results are in agreement with the French National Nutrition and Health Programme guidelines that include the promotion of daily consumption of fruits and vegetables(26).

We observed a significant association between high consumption of fruits and vegetables and survival after adjusting for major confounders. This result is consistent with earlier studies(19–21). In the European Prospective Investigation into Cancer and Nutrition study, a better adherence to a plant-based diet was associated with a reduced mortality risk in Southern Europe, but not in the UK or in Germany, after controlling for all known risk factors(15). Similarly, the ‘Olive oil and salad’ pattern was associated with longevity in an Italian elderly cohort(20).

Fruits and vegetables, which were not separate entities in our FFQ, are the main source of antioxidants that are the basis of the free-radical theory of ageing(44). According to this theory, a balance between free radicals and antioxidants increases life expectancy. Some authors hypothesise that plant foods promote the activation of immune functions or have protective properties(16,17). A recent literature review highlighted the effect of high concentrations of polyphenols, carotenoids, folic acid and vitamin C on mortality(13). High consumption of flavonoids, found mainly in fruits, could be associated with reduced mortality risk(42). The beneficial effects of fruits and vegetables could also be explained by their fibre content that modulates LDL-cholesterol level, insulin sensitivity and blood pressure(45), all conditions associated with increased mortality risk. This hypothesis is supported by the PREDIMED (Prevention con dieta Mediterranea) study that demonstrated a significant association between lower risk of death and baseline higher fibre intake and fruit consumption(44).

Our results are in agreement with the few studies that have investigated fish consumption and risk of death(20,22). A Japanese study found that high consumption of vegetables and fish in subjects older than 75 years is associated with better survival(17). Most of the published studies on the positive association between fish and lower mortality have been carried out in countries with traditional high fish consumption (Japan and Scandinavia). Other studies included fish consumption in the diet scores (e.g., the Mediterranean Diet Score) or in ‘healthy’ diet patterns(14,16,45) with contrasting results. Hoffman et al.(45) did not find any significant association between these dietary patterns and mortality. Conversely, Anderson et al.(16) observed a positive link between survival and a healthy dietary pattern (consumption of low-fat dairy products, fruits, wholegrains, poultry, fish and vegetables). The protective effect of fish consumption on health has been linked to the anti-inflammatory effects of the essential n-3 fatty acids(13,22).

Olive oil is the main source of fat in the traditional Mediterranean diet. Our study reported a beneficial effect only

<table>
<thead>
<tr>
<th>Table 3. Association between 10-year overall mortality and dietary habits in the Three-City elderly cohort (n 8937) (Crude and adjusted hazard ratios and 95% confidence intervals)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dietary habits</strong></td>
</tr>
<tr>
<td>At least 1 fruit and 1 vegetable, cooked or raw/day</td>
</tr>
<tr>
<td>Cooked fruits or vegetables: ≥4–6/week</td>
</tr>
<tr>
<td>Meat: ≥1 servings/day</td>
</tr>
<tr>
<td>Fish: ≥2 servings/week</td>
</tr>
</tbody>
</table>

*P < 0.005, **P < 0.01, ***P < 0.001.
† Cox proportional model adjusted for sex, centre, education (no or primary/secondary/high school/university), income (<1500 or >1500 euros/month), occupation (white collar/employee/blue collar/housewife).
‡ Cox proportional model adjusted for sex, centre, education, income and occupation and also for smoking status, alcohol consumption, history of CVD, BMI, depression, diabetes, hypertension, hypercholesterolaemia, dependence (instrumental activities of daily living scale), self-rated health, self-rated diet quality, number of drugs and number of chronic diseases.

<table>
<thead>
<tr>
<th>Table 4. Association between 10-year overall mortality and diet diversity in the Three-City elderly cohort (n 8937) (Crude and adjusted hazard ratios and 95% confidence intervals)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diet diversity</strong></td>
</tr>
<tr>
<td>Diversity diet score (4–5 v. 0–3)</td>
</tr>
<tr>
<td>Various fats (≥3 v. ≤3)</td>
</tr>
</tbody>
</table>

*P < 0.005, **P < 0.01.
† Cox proportional model adjusted for sex, centre, education (no or primary/secondary/high school/university), income (<1500 or >1500 euros/month), occupation (white collar/employee/blue collar/housewife).
‡ Cox proportional model adjusted for sex, centre, education, income and occupation and also for smoking status, alcohol consumption, history of CVD, BMI, depression, diabetes, hypertension, hypercholesterolaemia, dependence (instrumental activities of daily living scale), self-rated health, self-rated diet quality, number of drugs and number of chronic diseases.
among women. This finding is in agreement with the findings in
an elderly British cohort (7), where the Mediterranean style dietary
pattern was associated with reduced mortality only in women.
This sex-specific effect could be explained by women’s longer
life expectancy. Many studies support the beneficial effect of
the Mediterranean diet on mortality (27, 28). Masala et al. (18)
observed that the olive oil and salad dietary pattern (high
consumption of olive oil) is inversely associated with all-cause
mortality in the elderly. The PREDIMED study found that higher
consumption of olive oil could be explained by its high concentra-
tions of MUFA and phenolic compounds that improve endothe-
mium function and reduce oxidative stress, thereby promoting healthy ageing and longevity (13).

On the other hand, we found that daily consumption of meat,
as a broad category, had a negative effect on survival. Most previous studies showing a deleterious effect of meat
consumption on lifespan (17, 45) also found that high meat
consumption patterns were often associated with unhealthy
dietary habits such as high levels of fat consumption. However,
in other studies, red meat consumption was not associated with
increased mortality risk after correction for confounding factors (16). Comparisons with previous findings are limited by
the different definitions of meat consumption groups. In some
studies red meat with high content of FA was considered on its
own, whereas poultry or lean meat was not included in the
analysis. Anderson et al. (16) suggested that high consumption
of animal foods could increase the mortality risk, only if meat
replaces protective plant foods in the diet. The link between
red meat and dietary fat could affect the lipid and lipoprotein
profile, and thus CVD risk (45).

The association between diet diversity and mortality did not
remain significant after adjustment for confounders unlike in
other studies (27, 28). However, comparisons are difficult because
these studies used different methods of food collection and
different food groups.

The data from our study should be interpreted in the light of
the following limitations. First, the 3C sample is not represen-
tative of the French population. Indeed, compared with the
whole French population, this cohort included more urban
dwellers, in better health and living together (30). Therefore,
extrapolation of our results to the general population of
elderly should be made with caution. The FFQ did not record
quantitative data (portions, grams), but only frequencies of
consumption. Low-frequency consumption does not necessa-
arily mean lower energy intake, but simply suggests a lack of
diversity in eating habits. Moreover, the FFQ did not allow
calculating the total energy intake, as recommended to better
control for confounding factors and to reduce extraneous varia-
tion (48). In a previous article exclusively on the population
from the Bordeaux centre ($n = 1660$) of the 3C study, daily energy
intake was calculated in a sub-sample by using the 24-h dietary
recall technique. In this sub-sample, daily energy intake was
not affected by the frequency of consumption of fish, of fruits
and vegetables (frequent $v.$ less frequent) or by the use of
$n$-3- or $n$-6-rich oils (regular $v.$ non-regular) (49). Moreover, the
baseline energy intake among the Bordeaux sub-sample was
not significantly different between those who were dead ($n = 375$) or still alive ($n = 1422$) at the end of the 10-year follow-up
(data not shown). This suggests that energy intake is not a major
confounder in the present analyses. According to the literature,
mainly studies with the most accurate data on food consump-
tion (in daily amount) (3, 7, 15, 16, 18, 20–22, 43, 46) found significant
associations between dietary patterns and mortality. Our data
did not allow this level of detail. However, our results confirm
the benefit of several food categories on survival. Moreover, in
our study, the assessment of dietary intake covered only broad
food groups. This limitation is important for the interpretation of
the association between meat and survival, because the meat
group included both white meat (lean, healthy) and red meat
(fat, deleterious). The limitations of the FFQ used in this study
(few items, absence of validation, only baseline administration)
could have led to non-differential misclassification bias.

On the other hand, we found that daily consumption of meat,
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F. L. formulated the research question, carried out the statistical analysis and interpretation of the data and drafted the manuscript. T. M., J. S., C. F. drafted/revised the manuscript. L.-A. G. carried out the statistical analyses and revised the manuscript; C. B. was involved in data acquisition, analysis and interpretation of the data, study design, study supervision and drafting/revising of the manuscript.

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Supplementary material

For supplementary material/s referred to in this article, please visit http://dx.doi.org/10.1017/S000711451600266X

References