

## Original Article

## Does diet matter for survival in long-lived cultures?

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In 1987, the International Union of Nutritional Sciences (IUNS) subcommittee on Nutrition and Ageing, in conjunction with the World Health Organization (WHO) global program for the elderly, embarked on the 'Food Habits in Later Life' (FHILL): a cross-cultural study to determine to what extent health, social and lifestyle variables, especially food intake, collectively predict survival amongst long-lived cultures. A total of 818 participants aged 70 years and over, were recruited from five IUNS centres. Mortality data were collected after five to seven years. The cohorts included Swedes in Sweden (SWD), Greeks in Greece (GRS) and in Melbourne, Australia (GRM), Anglo-Celts in Australia (ACS) and Japanese in Japan (JPN). Information was obtained on health, lifestyle and diet at baseline. A Cox Proportional Hazard model containing ten potential predictors of survival, adjusted to age at enrolment and ethnicity/locality, was developed to analyse the survival data. Based on up to seven years survival data, it was found that being an elderly Greek in Australia conferred the lowest mortality risk and being an elderly Greek in Greece conferred the highest mortality risk. When the ten potential predictors of survival were entered into the Cox model, the memory score, the Mediterranean diet score, Activities of Daily Living (ADL) and general health status scores showed the greatest effects in significantly reducing mortality hazard ratios by 22%, 13%, 4% and 4%, respectively. For diet score, a one-unit change predicted a significant 13% difference in survival. Of the lifestyle (modifiable) variables entered in the multivariate model, exercise and social activity were not significant predictors of survival suggesting that diet is a more important predictor of survival than these variables. Another lifestyle variable, smoking, significantly increased mortality hazard ratios by 67%, making it a more important predictor of survival than diet. Being male (non-modifiable) also increased risk of death by 63%. Diet, particularly the Mediterranean Diet, operates irrespective and together with other factors as an appreciable contributor to survival, with a strength comparable to or greater than all other measured variables. The independence and strength of the predictiveness of food pattern for survival, and for this to be cross-cultural from Europe to Asia is a novel and important observation for food and health policy.

**Key Words:** elderly, Mediterranean diet, culture, survival, longevity, social factors, exercise, ADL, memory, smoking, gender, FHILL, Greeks, Swedes, Japanese, Anglo-Celts, Australians

### Introduction

The United Nations (UN) recently stated that "The number of persons aged 60 years or older is estimated to be 629 million in 2002 and is projected to grow to almost 2 billion by 2050, at which time the population of older persons will be larger than the population of children (0-14 years) for the first time in human history.<sup>1</sup> The World Health Organization (WHO) also released the Healthy Life Expectancy (HALE), a healthy life expectancy indicator based on the estimates of the number of years to be lived in 'full health'.<sup>2</sup> Japan, Australia, Sweden and Greece are amongst the leading HALE nations. Increasing longevity establishes the need for more attention to problems of nutrition and how it might influence disability and health in the elderly.

Social network,<sup>3</sup> social activity,<sup>4</sup> physical activity,<sup>5</sup> health status,<sup>6</sup> cognitive function,<sup>7</sup> Activities of Daily Living (ADL),<sup>8</sup> exercise,<sup>9</sup> nutrition<sup>10</sup> and lifestyle factors<sup>11</sup> have been known to be amongst the major predictors of survival. Such findings, however, are mainly based on analyses for single predictors or based on single populations or based on

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similar cultures.<sup>12</sup> The aim of the FHILL study was to determine to what extent health, social, and lifestyle variables, especially nutritional, collectively predict survival amongst long-lived cultures from five different communities.

### Subjects and methods

Between 1988 and 1991, information on social, physical, mental and dietary intakes were collected from five community-dwelling cohorts aged over 70 years, namely Swedes in Sweden (SWD), Greeks in Greece (GRS) and Australia (GRM), Anglo-Celts in Australia (ACS) and Japanese in Japan (JPN). A representative sample from each cohort was randomly selected with response rates between 64%-89%. The characteristics of each cohort are shown in Table 1. These cohorts were followed up to seven years when the deaths of 147 out of 818 participants were confirmed.

Table 2 describes the methods used in each FHILL cohort. Data on memory (score range 0-5), well-being (score range 0-7), general health (score range 33-74), exercise (score range 1-7), Activities of Daily Living (score range 15-62), social activity (score range 22-176), and social networks (score range 12-46) were collected by means of interviewer-administered questionnaires that were developed for the FHILL study.<sup>13,14</sup> Questionnaires (FFQ) were used in all cohorts to gather information on dietary intakes, with the exception of the Japanese cohort, where a 3-day 24-hour weighed food record method was used. The portion sizes of the foods consumed were recorded in household measures. To facilitate estimation of serving sizes, photographs of small and large portions were also used. The frequency of food consumption was subsequently quantified on a weekly basis.

Seasonal variation was taken into account by expressing the approximate number of weeks in which the food items were eaten as a fraction of a year. Intakes in

grams/week were calculated by multiplying the serving size (grams) by the weekly frequency of intake. As energy intake is a predictor of mortality and is associated with the composition of food intake, food intake in each food group was adjusted to 2500 kcal (10,460 kJ) for men and 2000 kcal (8368 kJ) for women.<sup>15</sup>

The Traditional Mediterranean Diet (TMD) score developed by Trichopoulou *et al.*,<sup>15</sup> has been shown to significantly reduce the risk of death amongst elderly Greeks in Greece<sup>15</sup> and Australia,<sup>16</sup> Anglo-Celts,<sup>16</sup> Danes,<sup>17</sup> Spanish,<sup>18</sup> and Chinese.<sup>19</sup> This Greek variant of the TMD in the 1960s was characterized by high consumption of olive oil (as a primary source of fat), high intakes of plant foods (cereals, legumes, vegetables, fruits and nuts), low intake of animal foods (meat, milk and dairy products) and moderate alcohol consumption. Accordingly, a similar method was adapted in the FHILL study by including a food group for fish to describe the Mediterranean Diet (MD). A gender-specific median value was used as a cut-off point and each food group intake above (vegetables, legumes, fruits and nuts, cereals, fish, and M:S ratio) or below (milk and dairy, meat and meat products, and alcohol) the median scored one. The scores from all food groups were summed into a MD score, which ranged between 0 and 9. It was hypothesized that a more varied diet with four or more of these food groups would have a beneficial health and survival effect and would resemble more closely the Mediterranean Diet. These considerations are based on collective epidemiological and biological evidence.<sup>12,20,21</sup>

### Ethics

Ethics approval of the IUNS study of Food Habits in Later Life (FHILL) was obtained from Monash University in Australia. In addition, ethics approval from other IUNS centres, namely Nagoya City University for participants in Japan and Gothenburg University for participants

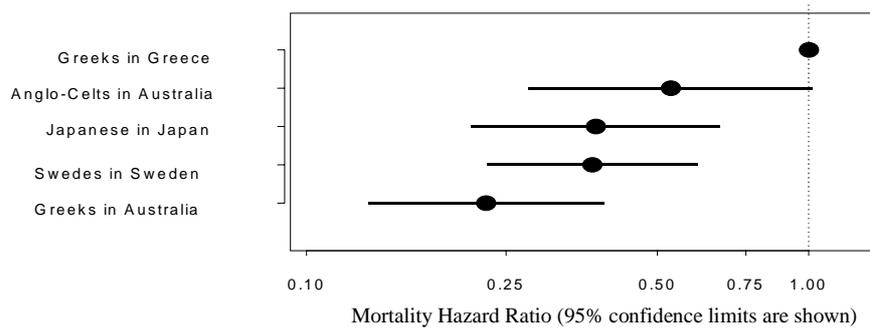
**Table 1.** Summary of FHILL cohort characteristics

Code	Location	Rural or Urban	Ethnicity	Sample Size			Age		
				Men	Women	Total	Mean	±	SD
JPN	Okazaki, Japan	Semi-urban	Japanese	43	46	89	77.18	±	5.7
SWD	Gothenburg, Sweden	Urban	Swedes	73	144	217	77.88	±	5.5
ACS	Melbourne, Australia	Urban	Anglo-Celtic	70	71	141	74.26	±	4.7
GRM	Melbourne, Australia	Urban	Greeks	94	95	189	77.58	±	6.2
GRS	Sparta, Markopoulou, Paiania, Greece	Rural	Greeks	91	91	182	76.27	±	4.5

**Table 2.** Summary of methods in IUNS FHILL mortality follow-up by community study

Code	Start	Response Rates	Follow-up	S	D	Q	Diet methods
JPN	1991	64%	1996, 1999	58	31	IUNS	3d 24-h weighed food record
SWD	1990	76%	1996	139	47	IUNS	Semi-quantitative FFQ
ACS	1990- 1992	70%	1996	127	14	IUNS*	Semi-quantitative FFQ
GRM	1990- 1992	84%	1996	165	24	IUNS	Semi-quantitative FFQ
GRS	1988-1990	89%	1993-1994	129	53	IUNS	Semi-quantitative FFQ

Start=Commencement of the study; Follow-up=Mortality follow-up; S=Number of Survivors; D=Number of Deceased; Q=Questionnaires used in the study; IUNS\*=modified from IUNS questionnaires; Diet method=dietary assessment methods used for the study.



**Figure 1.** The contribution of ethnicity and locality to mortality

in Sweden, were also acquired. Respondents, including their relatives, were given a thorough explanation of the nature of this study before verbal consent was attained. The information given by participants remained confidential.

### Statistical analysis

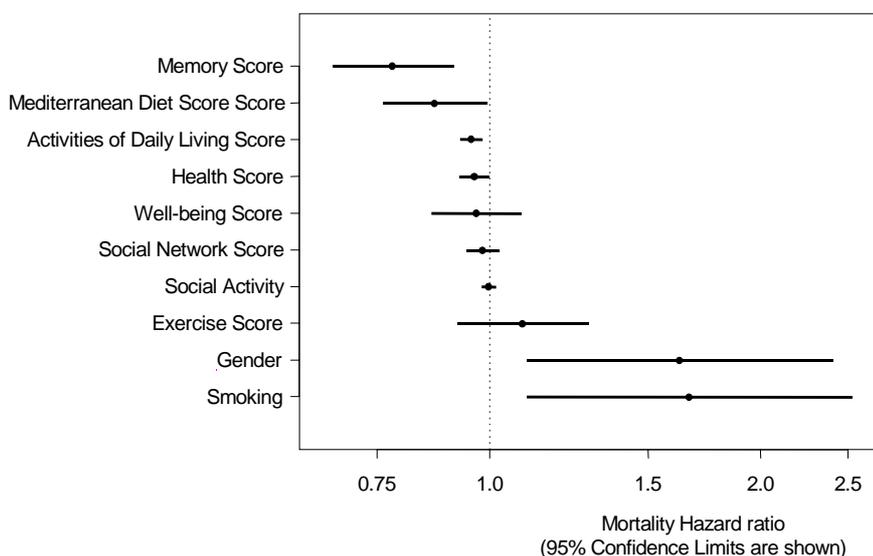
Statistical analysis was performed using the Statistical Analysis System (SAS) program for Windows.<sup>22</sup> For survival analysis, Cox Proportional Hazards procedure (PROC PHREG) was employed to calculate the mortality hazard ratio from selected variables (based on univariate Cox analysis) with all-cause mortality as the outcome. Significance was found from the univariate Cox model for all the variables incorporated in the multivariate Cox model. There were other potential predictors that were excluded from the multivariate model because they were not significant by themselves. These were the length of sleep and the absence of napping. The PHREG procedure performs regression analysis of survival data based on the Cox Proportional Hazards model. Dummy variables and strata statements were also created in the syntax.

Mortality hazard ratio according to baseline data and time-independent covariates such as age at enrolment (in 5-year intervals), were calculated by Cox's proportional

hazards regression model. This method took both the event of death and the time until its occurrence into account. Current smokers at enrolment included those who had stopped smoking within five years and non-smokers included those who had not smoked for more than five years. In order to examine the general predictors of mortality in elderly people from all cohorts, the Cox's model was also controlled for ethnicity/locality (0=Japanese in Japan, 1=Swedes in Sweden, 2=Anglo-Celts in Australia, 3=Greeks in Australia, 4=Greeks in Greece).

### Results

The effect of ethnicity and locality in predicting survival in the FHILL cohorts was considered using the Cox's Proportional Hazards model (Fig. 1). Greeks in Greece were used as the reference point (parameter estimate=0.00 and hazard ratio=1.00). For the four other FHILL cohorts, to be Greek in Australia conferred the lowest mortality hazard ratio (hazard ratio 0.23,  $P=0.0001$ ). The risk of death was also lower among Swedes in Sweden and Japanese in Japan (hazard ratio 0.37,  $P=0.0001$  and hazard ratio 0.37,  $P=0.0008$ , respectively). Similar findings were observed for Anglo-Celts in Australia, although the mortality hazard ratio did not reach significance



**Figure 2.** Predictors of mortality amongst older people adjusted for age, ethnicity and locality with all predictors shown integrated into one Cox Proportional Hazard regression model.

( $P=0.056$ ). Figure 2 presents the mortality hazard ratios of both modifiable and less modifiable variables in predicting survival. Memory score, Mediterranean diet, ADL, and general health status showed the greatest ability to reduce risk of death by 22% (9%-33%), 13% (1%-24%), 4% (2%-7%), and 4% (0.1%-7%), respectively. Of the lifestyle (modifiable) variables entered in the multivariate model, exercise and social activity were not significant predictors of survival suggesting that diet is a more important predictor of survival than these variables. However, another lifestyle variable, smoking, significantly increased mortality hazard ratios by 67%, (10%-150%), making it a more important predictor of survival than diet. Being male also increased risk of death by 63% (10%-140%). Other variables did not show significant association in predicting mortality.

### Discussion

Japan, Australia, Sweden and Greece are known to be amongst leading countries in long life expectancy.<sup>2</sup> In the current study, five cohorts from four longevity cultures from around the world were examined. Different ethnicities and localities were found to be significant predictors of survival. Moreover, it was revealed that being a Greek in Australia conferred the lowest mortality risk, followed by being a Swede in Sweden, a Japanese in Japan and an Anglo-Celtic in Australia, when Greeks in Greece were regarded as the reference ethnicity. These results were significant after controlling for age at enrolment, gender, and smoking status, except that for Anglo-Celtic ethnicity in Australia ( $P=0.06$ ) when the confidence limits were set at 95%.

Information on the effect of ethnicity and locality alone in predicting mortality are currently unavailable. There are several other cross-cultural longitudinal studies, such as the Seven Countries Study,<sup>23,24</sup> SENECA,<sup>12,25,26</sup> MONICA,<sup>10</sup> and CRONOS<sup>27</sup> that have examined health and nutrition in later life. However, the effect of ethnicity itself in predicting survival has not been examined.

Greeks in Greece had the highest mortality risk whilst Greeks in Australia had the lowest risk amongst longevity cohorts. There are several possible explanations for this result including the observations that self-rated health, social activity and social network scores for Greeks in Australia were higher than Greeks in Greece, and on average, Greeks in Australia consumed more vegetables, legumes, meat and fish than their counterparts in Greece.<sup>28</sup>

To date, very limited data are available from cross-cultural longitudinal studies to examine the interaction between social, physical activity and nutritional variables in predicting survival (all-cause mortality). Previous studies mainly focus on one or two predictors of mortality. In the FHILL study, all available predictors of mortality, less-modifiable variables such as gender, cognitive function, well-being, and health status, in addition to modifiable factors such as diet, ADL, social activity and network, exercise and smoking, were integrated into the one Cox model. It was found that better memory, better health status with limited disability and better diet score together prolonged survival. This is consistent with

SENECA findings<sup>12,29,30</sup> that adherence to healthy lifestyle behaviours provides the best collective prediction of survival in Europe.

Smoking increases the risk of death as previously reported by several authors.<sup>31,32</sup> In practice, diet is the most available, modifiable and powerful predictor of survival that we have examined in the FHILL study. Every one unit change in diet score accounted for 13% change in survival outcome over a period of up to 7 years. In contrast, being a non-smoker or ex-smoker of more than 5 years standing accounted for 67% change in mortality over the same period. Other authors have stressed the importance of smoking but this study was able to examine its impact on survival in the context of dietary and other variables. The other consideration about diet is that its measurement is subject to considerable error,<sup>33</sup> so that, this reported strength of dietary prediction is probably an underestimate. The memory score was also a relatively strong predictor of mortality (22% change in the score over the 7 year period). How amenable to change this score is remains uncertain.

There is a limitation in interpreting the magnitude of the mortality hazard ratio estimates as shown in Figure 2 since each predictor variable has its different units of measurement. For example, smoking and gender have large hazard ratios and wide Confidence Intervals because these variables are binary. On the other hand, score-type variables, such as memory and diet, have much lower hazard ratio estimates and narrow Confidence Intervals because the scale of measurement of these scores is considerably large.

### Conclusion

The FHILL cross-cultural study demonstrates that difference in ethnic background and locality of abode, contributes to difference in survival. Taking this into account, a range of potential predictors of survival, social, physical activities, and nutritional, along with health status, memory and well being are separate and collective predictors of survival. Gender is important in its own right - it does not alter the separate and collective importance of these survival predictors.

Diet operates irrespective and together with other factors as an appreciable contributor to survival beyond the age of 70 years in men and women, with a strength comparable to or greater than all other variables assessed in the FHILL study. We conclude that since exercise and social activity did not come out as predictors of survival in our study that diet, particularly the Mediterranean Diet, is more important than exercise or social activity for prediction of survival. This is not to say that exercise and social activity are not predictors of survival when other study designs are employed.

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