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The nutrition transition in the Republic of Ireland: trends in energy and nutrient supply from 1961 to 2007 using Food and Agriculture Organization food balance sheets

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Abstract

Over the course of the last 50 years the Republic of Ireland has gone from being one of the poorest countries in Europe to one of the richest; however, it is now experiencing increasing rates of obesity and non-communicable chronic disease. Although several national nutrition surveys have been carried out in Ireland since 1990, there is little information on the Irish diet before then. We analysed the FAO food balance sheets for Ireland from 1961 to 2007 in order to characterise the changes in energy and nutrient supply that took place during that period. Food balance sheets were downloaded from the FAOSTAT database and per capita supply of commodities was analysed using dietary analysis software. Energy from carbohydrate as a percentage of total energy fell from 55 % in 1961 to 46 % in 2007, whereas energy from fat increased from 29 % to 34 %; these values are well outside WHO recommendations for the prevention of chronic disease. Energy from alcohol as a percentage of total energy has doubled within the last 20 years. On a nutrient-density basis, vitamins and minerals met or exceeded WHO recommendations, apart from vitamin D, folate, Ca and Fe. Although there are methodological limitations associated with the use of food balance sheets, the present results demonstrate that the current imbalances in the Irish diet were already evident several decades ago. Because they are so long established, they will be difficult to reverse unless major public health nutrition interventions are implemented.

Key words: Food balance sheets: FAOSTAT: Nutrition transition: Republic of Ireland

Over the course of the last 50 years the Republic of Ireland has gone from being one of the poorest countries in Europe to one of the richest[1]. After decades of economic stagnation and underperformance following the Second World War, an economic boom that later became known as the 'Celtic Tiger' began during the second half of the 1980s, gathered pace during the mid- and late-1990s, and continued for much of the last decade before coming to an abrupt end in 2008 due to the global financial crisis[2,3]. At the same time as this economic transformation was taking place, a health and lifestyle transition was occurring in the Republic of Ireland that saw life expectancy at birth increase from 69·7 years in 1960 to 79·4 years in 2008[4]. However, there is now growing concern that these gains in life expectancy are being partly offset by increasing rates of obesity and non-communicable chronic diseases[5–14].

Over the last few decades there has been a sharp increase in the prevalence of obesity among both adults and children in the Republic of Ireland. In 1990, some 40 % of Irish adults were overweight and a further 10 % were obese[15], whereas by 2007 the proportion of adults in the obese category had risen to 25 %[16]. Between 1970 and 2002, the average body weight of 14-year-olds in the Republic of Ireland increased by 30 % in boys and by 20 % in girls[10]. In 2002, some 23 % of boys and 28 % of girls between the ages of 4 and 16 years were either overweight or obese[17]. Between 1990 and 2005, there was a two- to fourfold increase in obesity in children aged 8–12 years[18].

Excessive body fat leads to serious health consequences including CVD (mainly heart disease and stroke), type 2 diabetes, musculoskeletal disorders such as osteoarthritis, and some cancers (for example, endometrial, breast and colon)[19]. Cancer incidence and mortality rates in the Republic of Ireland are among the highest in Western Europe[20,21], and it is estimated that one in every three individuals will develop cancer by the age of 75 years[21]. Cancer incidence increased between 1994 and 2004, with the rate for all cancers (excluding non-melanoma skin cancer) increasing by 1·4 %

Abbreviations: NTD, neural tube defect; QFFQ, quantitative food-frequency questionnaire.

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per annum in males and by 1·1 % per annum in females[21]. Cancer has now overtaken CHD as the most common cause of death in the Republic of Ireland, accounting for 29 % of all deaths in 2006[22]. In contrast to cancer, CHD mortality rates in the Republic of Ireland have declined in recent years, mainly due to improvements in medical treatments and favourable population changes in some risk factors, including smoking, cholesterol and blood pressure[12–14,23]. Nevertheless, CHD remains a major cause of death, accounting for 18 % of deaths in 2006[22]. Moreover, there is evidence from prescription data that prevalence rates for CHD increased significantly between 1990 and 2002[24]. Prevalence rates for heart attack and angina in 2007 were 3·8 % and this figure is projected to increase to 4·6 % by 2020[25]. Hypertension is the most common medical condition in Ireland[26]; in 2007 its prevalence in Irish individuals aged ≥ 16 years was 25·1 %[25] and this figure is expected to rise to 28·3 % by 2020. The risk of hypertension increases dramatically with age, and recent estimates put the prevalence of hypertension in middle-aged Irish adults at approximately 50–60 %[16,26]. Diabetes prevalence in Irish adults is also increasing. In 2000, the International Diabetes Federation Atlas[27] estimated that 3·2 % of all individuals aged 20–79 years in the Republic of Ireland were affected by diabetes (type 1 and type 2 combined, diagnosed and undiagnosed); however, by 2010 this figure had increased to 5·2 %[28]. Using the Public Health Observatories/Brent/ScHARR (PBS) Diabetes Population Prevalence Model[29], the prevalence of adult diabetes (type 1 and type 2 combined) in the Republic of Ireland in 2005 was estimated at 4·7 %, and it was forecast to rise to 5·9 % by 2020[25]. The total direct cost of treating type 2 diabetes in 2003 was approximately €580 million, or 6·4 % of overall healthcare expenditure[9].

Because of the fact that many chronic disease risk factors are modifiable by diet[30–33], national nutrition surveys play an important role in epidemiological research and the development of food and nutrition policies. Over the past 60 years, six national nutrition surveys have been carried out in the Republic of Ireland[15,16,34–37]. However, all except one were carried out within the last 20 years. Thus there are major gaps in our knowledge about the nutritional composition of the Irish diet before the 1990s and about the trends that were becoming established during that time.

At their crudest level, dietary trends can be followed using national food balance sheets that are compiled annually by the FAO[38–40]. Through the use of aggregate data on food production, imports, exports and non-food utilisation, these food balance sheets provide estimates of the total amounts per head of population of the many dozens of food commodities that are available for consumption within a country during any given year. This information can be used to monitor the overall changes taking place in food and nutrient supply within[41–45] and between[46–56] countries over many years. A limitation of food balance sheets is that although they provide information on per capita energy, protein and fat supply, they provide no information on carbohydrates, dietary fibre, fatty acids, amino acids, minerals or vitamins. This limitation can be overcome by coding the commodities using dietary analysis software[41,45]. The objective of the present study was to analyse the food balance sheets for the Republic of Ireland from 1961 to 2007 in order to track the changes that took place in per capita energy and nutrient supply in the country during this period. We describe these changes and discuss their implications in relation to the WHO guidelines for nutrition and prevention of chronic disease[33].

Methods

FAO food balance sheets for the period 1961–2007 were downloaded as csv files from the FAOSTAT database[57]. These food balance sheets provide overall per capita supply (as kg/year) for food commodities including cereals, starchy roots, vegetables, fruits, oilseeds and oilseed oils, treenuts, animal fats, milk, meats, eggs and fish. The full list of commodities is shown in Appendix 1. Having imported the data into Microsoft Office Excel 2003 (Microsoft Corp., Redmond, WA, USA), per capita supply was then converted to g/d.

In order to determine the trends in energy and nutrient supply the commodities were coded and entered into WISP dietary analysis software (Tinuviel Software, Llanfechell, Anglesey, UK). The food composition databank supplied with this software is from *McCance and Widdowson's The Composition of Foods*, 5th and 6th editions plus supplements[58]. For consistency and wherever possible, foods were coded as being in their most unprocessed form (for example, 'bananas, weighed with skin', 'barley, whole grain, raw'). However, certain broad categories (such as fish, treenuts and those labelled as 'other') were lacking in detail about the specific foods that made up the category. To code these categories in a way that would reflect the Irish diet more closely we referred to the food list of a quantitative FFQ (QFFQ) that was developed recently by one of the authors (T. S.). The QFFQ is based on food intake data from three 24 h dietary recalls (two weekdays, one weekend day) collected in consecutive months starting in November 2008 from a non-random female university student population (*n* 64, aged 17–23 years) in Cork, Republic of Ireland. All foods reported more than once were included on the draft QFFQ. These foods were organised into coherent groupings to give a 207 line-item final instrument, the performance of which has since been compared and found to give good overall agreement with nutrient intakes from 4 d estimated food diaries in a group of forty-eight female students aged 18–25 years (T Sheehy, D Crowley, E Lally, A McAteer, E Morrisey, D O'Connor and G Tynan, unpublished results). Using the food list of this QFFQ as a guide, we populated the category 'pelagic fish' with herring, mackerel, sardines and tuna, 'demersal fish' with cod, haddock and plaice, 'freshwater fish' with salmon and trout, and 'crustaceans' with prawns, crab, lobster and shrimps. The category 'pulses (other)' was populated with split peas, lentils and chickpeas, while 'treenuts' were coded as almonds and cashew nuts. The category 'vegetables (other)' was populated with cabbage, carrots, broccoli, Brussels sprouts, cauliflower, celery, parsnip, turnip, courgette, leeks, mushrooms, beetroot, spinach, cucumber and lettuce. 'Fruits (other)' contained blackcurrants,

currants, kiwi fruit, peaches, nectarines, plums, raspberries, strawberries, pears and watermelon, while ‘citrus (other)’ contained satsumas. For categories where this procedure was carried out, supply was divided equally among the constituent foods; none of these categories contributed more than about 1 % of energy. Overall, the commodities we coded accounted for over 96 % of the total energy supply. We excluded certain minor categories such as tea, coffee, other sweeteners and spices either because of low energy contribution or lack of information.

In order to check the level of agreement between our calculated values for daily per capita energy, protein and fat supply and the estimates provided on the food balance sheets themselves, we obtained Pearson correlations using Microsoft Office Excel 2003. Statistical significance of correlations was accepted at the 5 % level. All tests were two-sided.

Results

Fig. 1 shows the relationship between the FAO food balance sheet estimates for (a) energy; (b) protein; and (c) fat supply in the Republic of Ireland and our calculated values using WISP software. Our values for energy supply were,

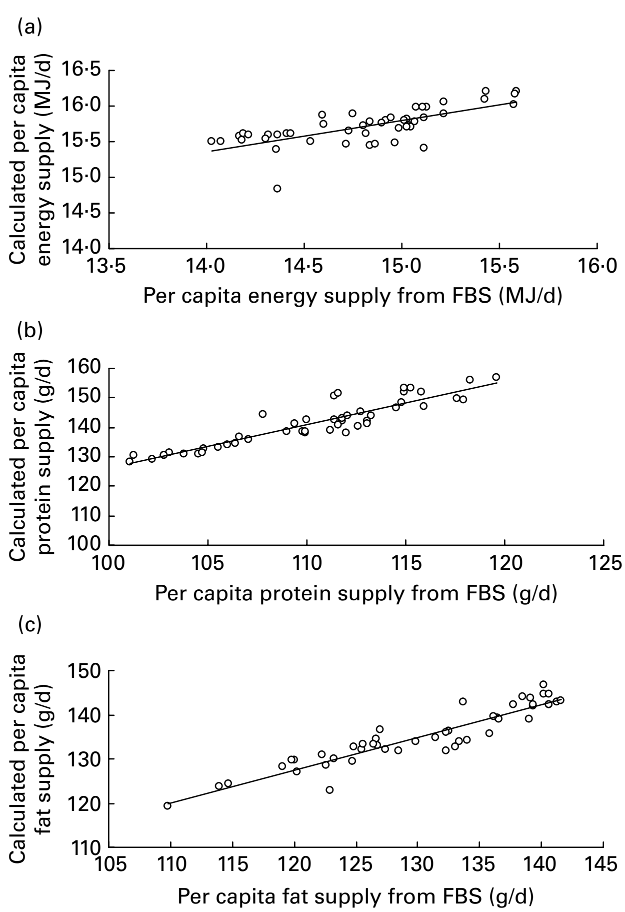

Fig. 1. Relationship between food balance sheet (FBS)-derived and calculated values for (a) energy ($y = 0.4316x + 9.3217$; r 0·7101), (b) protein ($y = 1.4919x - 23.273$; r 0·9231) and (c) fat ($y = 0.7373x + 39.035$; r 0·9321) supply in the Republic of Ireland.

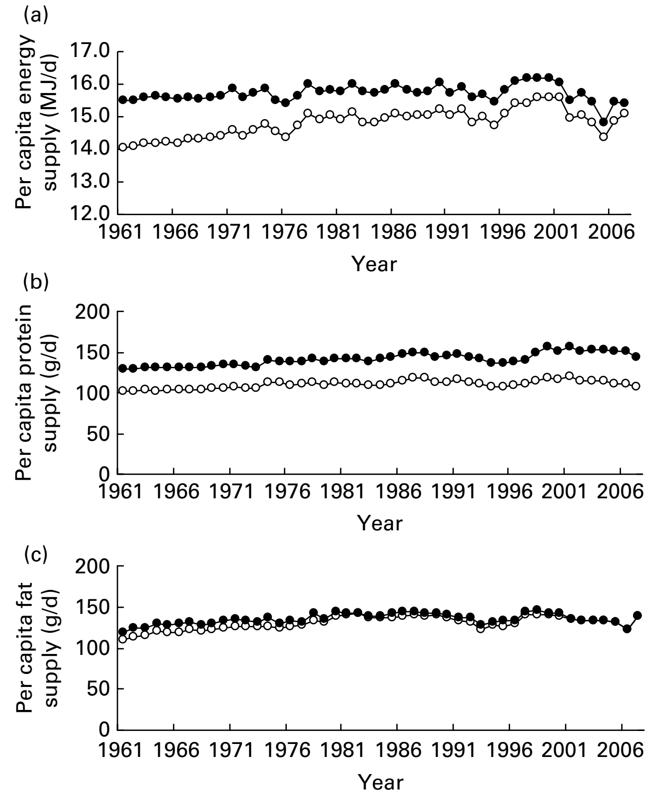

Fig. 2. Trends in food balance sheet-derived (–○–) and calculated (–●–) supply of (a) energy, (b) protein and (c) fat in the Republic of Ireland between 1961 and 2007.

on average, 5·6 % higher than the food balance sheet estimates; however, the relationship between them was statistically significant (r 0·7101; $P < 0.0001$). Our values for protein supply were, on average, 28 % higher than the values shown on the FAO food balance sheets; again, however, the relationship between them was statistically significant (r 0·9231; $P < 0.0001$). For fat supply, our calculated values were 3·7 % higher than those shown on the FAO balance sheets; once again, the relationship between them was statistically significant (r 0·9321; $P < 0.0001$).

Fig. 2 shows the trends in (a) energy, (b) protein and (c) fat supply between 1961 and 2007 according to the food balance sheets and our calculated values using WISP software. According to the food balance sheets, total per capita energy supply increased by some 1084 kJ (259 kcal)/d between 1961 and 2007. However, according to our calculations, per capita energy supply in 1961 was actually 67 kJ (16 kcal) higher than in 2007. This discrepancy between the food balance sheet estimates for energy and our calculated values was evident up to the 1990s; however, the difference between them was minimal after that. Per capita protein supply was about 7 g/d higher in 2007 compared with 1961 according to the food balance sheets, and by 16 g/d according to our calculations. There was also a gradual increase in per capita fat supply over the same period; fat supply was 29 g/d higher in 2007 according to the food balance sheets and approximately 20 g/d higher by our calculations.

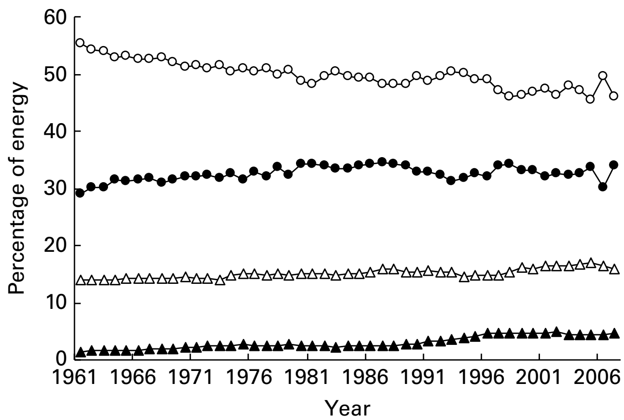

Fig. 3. Calculated percentage contributions to total energy supply of carbohydrate (–○–), fat (–●–), protein (–△–) and alcohol (–▲–) in the Republic of Ireland from 1961 to 2007.

Fig. 3 shows the calculated percentage contributions of proteins, fats, carbohydrates and alcohol to total energy supply between 1961 and 2007 according to our analysis using WISP software. Energy from carbohydrate fell steadily from 55 % in 1961 to 46 % in 2007. In contrast, fats provided only about 29 % of energy in 1961 whereas by 2007 this figure had reached 34 %. Protein has remained relatively constant at between 14 and 17 % of energy throughout the study period. Alcohol made only a minor contribution of about 1·5–2·5 % of energy up to the mid-1980s but increased steadily since then; in 2007 alcohol contributed 4·6 % of energy.

Fig. 4(a) shows our calculated values for the percentage contribution to energy of SFA, MUFA and PUFA between 1961 and 2007. Between 1961 and the late 1970s the food supply was characterised by a high level of saturated fats (> 15 % of energy), a moderate level of monounsaturated fats (8–10 % of energy) and a low level of polyunsaturated fats (< 3 % of energy). Saturated fats reached a maximum of 16·8 % of energy in 1978. Between then and the early 1990s the saturated fat content of the food supply fell to about 12 % of energy while the polyunsaturated fat content rose to 6 % of energy. This resulted in an increase in the polyunsaturated:saturated ratio from 0·16 in 1961 to 0·45 in 1993. There has been relatively little change in the proportions of saturated, monounsaturated and polyunsaturated fats in the food supply since then. In 2007, saturated fats provided 12·4 % of energy, with monounsaturated and polyunsaturated fats contributing 11·4 and 6·8 % of energy, respectively.

Fig. 4(b) shows our calculated values for sugars, starch and fibre supply between 1961 and 2007. Per capita fibre supply fell from 44 g/d in 1961 to about 36 g/d in 1976, but has tended to increase since then and in 2007 was 43 g/d. Energy from sugars fell from 22·3 % of total energy in 1961 to 17·4 % in 2007. Energy from non-milk extrinsic sugars fell from 16 % of energy in 1961 to 9 % in 2007. The ratio of sugars: starch has fallen slightly from 0·68 in 1961 to 0·61 in 2007.

Fig. 5(a)–(c) show the trends in fat-soluble vitamin, water-soluble vitamin and mineral supply from 1961 to 2007. Values are expressed on a nutrient-density basis as percentage of the mean WHO/FAO recommendations for male and female adults aged 19–50 years (see Appendix 2) per 10 MJ (2390 kcal) energy. Data for biotin and pantothenic acid are not shown and there was insufficient food composition information to calculate vitamin K supply. Overall, vitamin supply met the recommendations throughout the period apart from vitamin D, folate, vitamin A and vitamin E. Vitamin D supply ranged from 24 to 60 % of the recommendation (5 μg/d) while folate supply varied between 75 and 100 % of the recommendation (400 μg/d). Vitamin E increased from 78 % of the recommendation (8·75 mg/d) in 1961 to 153 % in 2007. Vitamin A, on the other hand, fell from 134 % of the recommendation (550 μg/d) in 1981 to 84 % in 2006. All minerals met the recommendations apart from Ca and Fe. Ca supply has ranged from 70 to 95 % of the recommendation (1000 mg/d) while Fe supply has fluctuated between 85 and 105 % of the recommendation (14·4 mg/d).

Fig. 6 shows the contribution of the major commodities to total energy supply between 1961 and 2007. Wheat contributed 29 % of energy in 1961 but by 1981 its contribution had fallen to 20 %, where it has more or less remained ever since. Sugar provided 15 % of energy between 1961 and the early 1970s but since then supply has been in decline; in 2007 sugar provided 7·5 % of energy. Milk provided up to 17 % of energy in the late 1970s but now provides only about 10 % of energy. Potatoes provided 7·6 % of energy in 1961 but by 2007 the value had fallen to 5·3 %. The overall contribution of meat has increased from 8 to 11 % of energy; within the meat category, mutton's contribution to energy fell from 2·0 to 0·9 %, but this was more than offset by the increased popularity of poultry and pig meat (data not shown). The contribution of butter to energy was in gradual decline between 1961 and 1983, falling from 9·5 to 7·4 %. However, over the next 7 years this value fell sharply to less than 2 % of energy. Butter usage was replaced by rapeseed oil, which rose from < 1 % of energy to approximately 5 % over the same period. Beer contributed < 3 % of energy

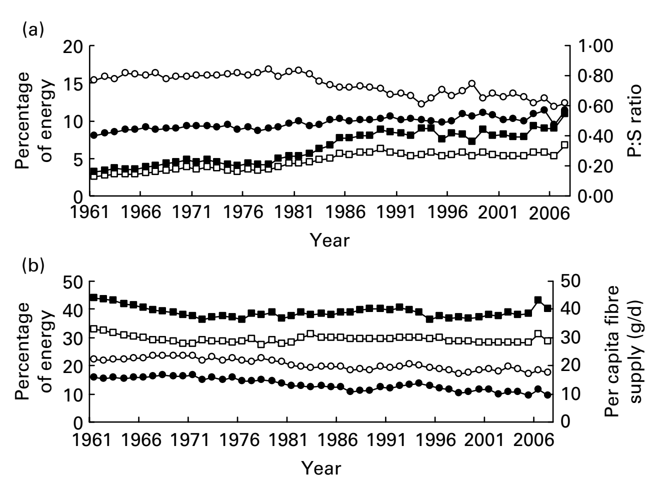

Fig. 4. Calculated trends in (a) per capita supply of SFA (–○–), MUFA (–●–) and PUFA (–□–) (all expressed as percentage contribution to energy), and polyunsaturated:saturated (P:S) ratio (–■–), and (b) per capita supply of total sugars (–○–), non-milk extrinsic sugars (–●–) and starch (–□–) (all expressed as percentage contribution to energy), and fibre (–■–; g/d) between 1961 and 2007.

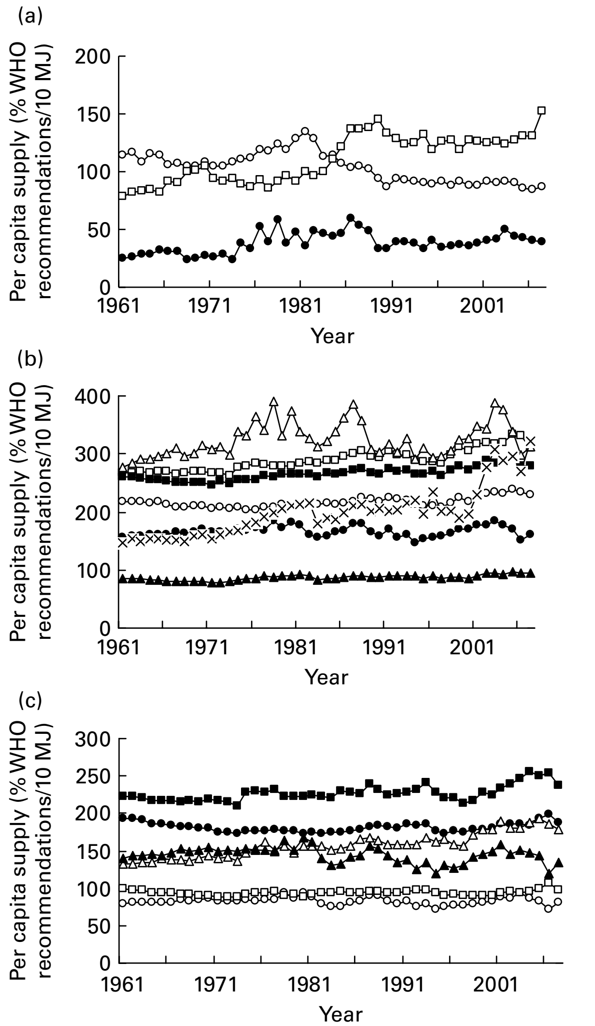

Fig. 5. Per capita supply of (a) fat-soluble vitamins (–○–, vitamin A; –●–, vitamin D; –□–, vitamin E), (b) water-soluble vitamins (–○–, vitamin B_1; –●–, vitamin B_2; –□–, niacin; –■–, vitamin B_6; –△–, vitamin B_{12}; –▲–, folate; – × –, vitamin C) and (c) minerals (–○–, Ca; –●–, Mg; –□–, Fe; –■–, Zn; –△–, Se; –▲–, iodine) in the Irish food supply from 1961 to 2007. Values are expressed as percentage of WHO recommendations (see Appendix 2) per 10 MJ energy.

between 1961 and the late 1980s but this value more than doubled to 7·2 % by 2002. In 2007, beer contributed 5·5 % of energy in the Irish food supply.

Discussion

The objective of the present study was to analyse the commodity data from the FAO food balance sheets for the Republic of Ireland from 1961 to 2007 in order to determine how the country's energy and nutrient supply has changed over recent decades. Overall, there has been a gradual increase in protein and fat supply since the 1960s, consistent with what has happened in most parts of the world[33]. For both protein (Fig. 1(b)) and fat (Fig. 1(c)), there were excellent correlations between the values we obtained using WISP dietary analysis software and those provided on the food balance sheets themselves. For energy supply, however (Fig. 1(a)), the level of agreement was not as good. According to the food balance sheets, per capita energy supply increased by some 1084 kJ (259 kcal)/d between 1961 and 2007 (Fig. 2(a)). Our calculated values, on the other hand, suggest that energy supply hardly changed at all over this time period. On investigating this discrepancy, we discovered that the energy conversion factors used in the Irish food balance sheets for certain important commodities (including wheat, sugar, milk, butter, mutton and potatoes) were at least 10 % lower than those used in WISP software. Also, some were inconsistent. For example, during the 1960s, the average factor for wheat in the food balance sheets was 10·88 kJ/g (2·600 kcal/g), whereas during the 1990s and 2000s it was ≥ 11·30 kJ/g (2·701 kcal/g). The gradual decline in these six commodities as a proportion of the overall food supply (Fig. 6) and the increase in the energy factor for wheat were the main reasons why the curves for energy supply in Fig. 2(a) more or less converged by the end of the 1990s.

In common with most countries, the Republic of Ireland has been experiencing an obesity epidemic in recent decades, the precise cause of which is as yet unknown. Obesity arises as a consequence of how the body regulates energy intake, energy expenditure and energy storage, and increases in obesity rates must reflect a state of positive energy balance[59]. The first national nutrition survey in the Republic of Ireland in 1948 reported very high average food energy intakes of approximately 12·97 MJ/d (3100 kcal/d)[34], whereas more recently, average daily energy intakes from food were reported to be 9·75 MJ (2330 kcal) in 1990[15], 9·84 MJ (2352 kcal) in 1998[35], 8·79 MJ (2101 kcal) in 1997–99[36], 9·87 MJ (2359 kcal) in 2002[37] and 9·53 MJ (2278 kcal) in 2007[16]. According to our calculations using WISP software, per capita energy supply in 2007 was 15·40 MJ (3666 kcal), which was lower than energy supply in 1990 (16·05 MJ (3819 kcal)). The corresponding food balance sheet's estimate for energy supply in 2007 was 15·11 MJ (3612 kcal), compared with 15·21 MJ (3636 kcal) in 1990. These figures suggest that the dramatic increase in obesity rates that occurred over the past two decades did not come about because of an increase in energy intake but

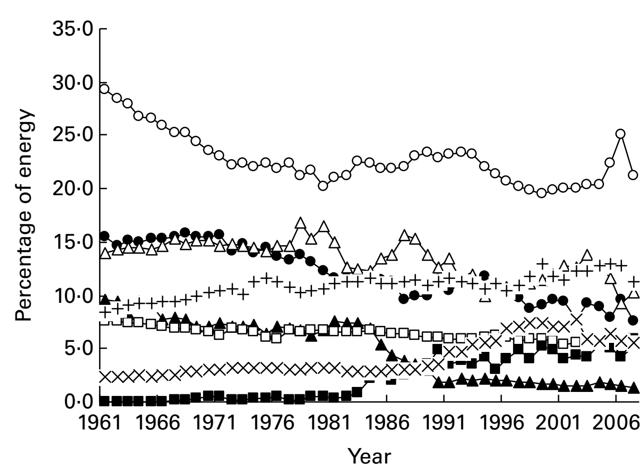

Fig. 6. Percentage contribution of selected commodities (–○–, wheat; –●–, sugar; –△–, milk; –▲–, butter; –□–, potatoes; –■–, rapeseed oil; – × –, beer; – + –, meat) to total energy supply in Ireland from 1961 to 2007.

must be related to reduced physical activity, allied possibly to changes in the macronutrient balance of the food supply. The first comprehensive analysis of habitual physical activity levels (including work, recreational and household activities) in a nationally representative sample of the Irish population was carried out in the late 1990s and showed that physical activity levels in Irish adults were low, with television viewing occupying most of the leisure time of men and women[60]. When physical activity levels in Irish adults were compared across the 1998, 2002 and 2007 SLÁN (Survey of Lifestyle, Attitudes and Nutrition) surveys[16] it was found that the percentage of adults who reported they took no exercise in an average week was 23 % (1998), 28 % (2002) and 19 % (2007), while the percentage reporting moderate and/or strenuous exercise three or more times per week for at least 20 min each time was similar across the three surveys: 38 % (1998), 40 % (2002) and 41 % (2007). Thus it appears that the majority of the Irish population does not partake in sufficient levels of physical activity. It has been hypothesised[59] that biological regulation of energy balance is optimum at a high level of energy flux and there may be a threshold of physical activity below which energy balance regulation is least sensitive. One of the most controversial areas of obesity research is the role of diet composition on body weight. Hill[59] argued that when individuals are in a state of energy balance, a gradual increase in dietary fat could promote weight gain because of the lower thermic effect of fat compared with carbohydrate and the greater voluntary intake associated with high-fat *v.* low-fat diets. Although there has been an increase in the contribution of fat to total energy supply in Ireland since the early 1960s (Fig. 3), the greater part of this shift occurred before the 1980s, and therefore would appear to have preceded the onset of the obesity epidemic. The increased contribution of alcohol to total energy appears to be more closely related in time to the period when obesity rates began to rise, but whether the relationship was causal or simply a reflection of other societal changes is unclear. The role of alcohol as a risk factor for obesity is controversial[61]. In the short term, energy consumed as alcohol is additive to that from other dietary sources, leading to short-term passive overconsumption of energy when alcohol is consumed; indeed, alcohol consumed before or with meals tends to increase food intake. In contrast, epidemiological studies suggest that in the longer term, mild to moderate alcohol intake may be more likely to protect against rather than promote weight gain. Other dietary and environmental factors that may play a role in promoting positive energy balance include high dietary energy density, high-glycaemic diets, sugars from beverages, high-fructose sweeteners, food advertising, and increased food portion sizes, variety, affordability and accessibility[59]. Although these factors are clearly relevant with respect to the modern Irish food supply, elucidating their possible contribution to the obesity epidemic requires further study.

Comparing the composition of the Irish food supply with the WHO recommendations, the WHO recommends that 55–70 % of dietary energy should come from carbohydrate and 15–30 % should come from fat[33]. The present results (Fig. 3) indicate that only in one particular year (1961) did the Irish food supply meet these recommendations. Since then, energy from carbohydrate has been falling at a rate of about 0·15 % per year, resulting in an overall decrease from 55·4 % of energy in 1961 to 46·1 % in 2007. On the other hand, energy from fat and protein has been rising at rates of 0·04 and 0·05 % per year, respectively, giving an overall increase from 29·2 to 34·1 % energy from fat and 13·9 to 15·8 % energy from protein over the same time period. These trends have persisted for so long that there appears to be little if any possibility of a significant reversal taking place in the foreseeable future unless major public health nutrition initiatives are put in place to try to redress the balance. Regarding alcohol, the sharp increase in alcohol supply during the 1990s that is evident in Fig. 3 has also been noted by other authors[62]. The present results show that these increased levels of alcohol supply were maintained throughout the last decade. This is a very worrying development, as alcohol-related problems cost Irish society in excess of €2·65 billion in 2003[63]. The fact that beer contributed more than potatoes to overall energy supply in the Republic of Ireland over the last 10 years (Fig. 6) is truly remarkable.

The WHO recommends that SFA should provide < 10 % of dietary energy and PUFA should provide between 6 and 10 % of energy[33]. The present results indicate that quite a dramatic shift in the fatty acid profile of the Irish food supply has occurred over the last 50 years (Fig. 4(a)), bringing it more into line with these recommendations. In 1961, some 15·4 % of energy came from SFA, compared with only 8·0 and 2·5 % from MUFA and PUFA, respectively. However, by 2007, energy from SFA had fallen to 12·4 %, while energy from MUFA and PUFA had increased to 11·4 and 6·8 %, respectively. The main reason for this shift was the sudden increase in vegetable (in this case, rapeseed) oil supply that occurred during the 1980s (Fig. 6), coupled with the continuous decline in butter usage since the 1960s. Vegetable oil usage increased markedly throughout much of the world during the 1970s and 1980s, fuelled apparently by an aggressive publicity campaign by the vegetable oil industry against saturated fats because of their tendency to raise blood cholesterol, which led to the reformulation of products on a massive scale by food manufacturers[64,65]. The changing pattern of fat supply in the Republic of Ireland since the late 1970s has resulted in a doubling of the polyunsaturated: saturated ratio from 0·21 to 0·42 (Fig. 4(a)). Although the polyunsaturated:saturated ratio has been shown to be strongly and inversely related to CHD risk in adults[66], the WHO has not made any recommendations; however, the UK Department of Health recommended that it should be between 0·23 and 0·45[67].

The sugars content of the Irish diet has been giving cause for concern because of its possible effects on micronutrient dilution and overall diet quality[68]. Between 1961 and 2007 the contribution of total sugars to energy in the Irish food supply fell at a rate of about 0·12 % per year from its initial value of 22·3 % (Fig. 4(b)). However, sugars still provided > 17 % of energy in 2007. The WHO recommendation for sugars is that ‘free sugars’ should provide < 10 % of energy in the diet[33]. Free sugars are also referred to as non-milk extrinsic sugars, and include all monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey, syrups and fruit juices. The present results indicate that non-milk extrinsic sugars supply in the Republic of Ireland has been falling, but was still in excess of 10 % of energy every year since 1961 apart from 2002, 2005 and 2007.

The WHO recommendations for fibre are > 25 g total dietary fibre per d or > 20 g NSP per d[33]. The present results show that per capita supply of NSP fell by about 10 % from 44·2 to 40·1 g/d between 1961 and 2007 (Fig. 4(b)). When expressed on a nutrient-density basis this represents a fall from 28·5 to 26·0 g per 10 MJ/d. Although these data suggest that fibre supply is adequate, they do not take into account losses that occur after the retail level, such as those due to peeling of fruits and vegetables[49].

Recent studies[16,69–79] have drawn attention to the fact that certain sections of the Irish population have inadequate intakes of micronutrients, the most important being vitamin D, folate, Ca and Fe[16]. The present results (Fig. 5(a)–(c)) show that for the majority of micronutrients, per capita supply (expressed per 10 MJ energy) exceeded WHO recommendations[80] throughout the period between 1961 and 2007. However, supplies of Ca, vitamin D and folate were below the WHO recommendations – substantially so in the case of vitamin D – and Fe has been borderline. Ca is required for normal growth and development as well as maintenance of the skeleton, and evidence indicates that dietary Ca intake is inadequate for maintenance of bone health in a substantial proportion of some population groups in Ireland, particularly adolescent girls and older women[81]. Vitamin D is essential for intestinal Ca absorption and the maintenance of Ca homeostasis and skeletal integrity[82]. Cutaneous synthesis of vitamin D from sunlight exposure in the Republic of Ireland is limited because of the country's geographic location (approximately 51–55°N) and cloudy climate, and there is a reliance on dietary sources during the winter months to help maintain adequate vitamin D status. Poor vitamin D status has been reported in a number of subgroups in the Irish population, including pregnant women[79], children and adolescents[83] and older individuals[83–86], and vitamin D insufficiency is also widespread in the general adult population, especially during wintertime[87]. Recent studies have shown that dietary vitamin D intakes of at least 7·2 μg/d are required to maintain serum 25-hydroxyvitamin D concentrations above even the lowest (25 nmol/l) cut-off point for adequacy during wintertime in the vast majority (>97·5 %) of Irish adults[88]. The present results indicate that the level of vitamin D in the food supply over the last four decades has been consistently lower than this (<3 μg/10 MJ energy). With increasing attention being focused on diseases associated with ageing, and the baseline cost of falls and fractures in older individuals being estimated at over €400 million per annum[89], there is clearly a need for strategies to increase the vitamin D and Ca status of the Irish population. The critical role of folate in preventing neural tube defects (NTD) is well established[90–94]. For almost two decades health authorities have been recommending that women who could become pregnant should increase their dietary folate intake and take a daily supplement of 400 μg folic acid[95–97]. The Republic of Ireland has higher rates of NTD-affected pregnancies than many other European countries, and because the option of termination is illegal this makes primary prevention an important issue[98]. Recognition that typical folate intakes in the Republic of Ireland are suboptimal for NTD prevention and that health promotion campaigns aimed at increasing folic acid supplement intake have been ineffective led to a recommendation – accepted by Government – to initiate mandatory folic acid fortification of bread[99]. However, this decision was later put on hold because of emerging concerns about the safety of high folic acid intake[100]. According to our calculations, the folate content of the Irish food supply has increased from about 320 to 380 μg/10 MJ energy since the early 1970s, a period during which NTD prevalence has declined significantly[101]; however, it remains well below the levels deemed optimal for NTD prevention. Unless the decision to suspend the roll-out of mandatory fortification is reversed, or voluntary folic acid fortification by food companies is increased considerably (both of which appear unlikely), or unless other effective ways of increasing the folate status of women of child-bearing age are identified, Irish women will continue to be inadequately protected against the risk of having avoidable NTD-affected pregnancies.

Overall, it is evident from the present study that there are long-standing imbalances in the Irish food supply in comparison with WHO recommendations[33] and that public health action will be needed to prevent the adverse consequences of these inappropriate dietary patterns and physical inactivity. The WHO recommends a number of policy principles that should be considered when developing national strategies to reduce the burden of diet- and physical inactivity-related chronic diseases[33]. These principles include the need for governments to work together with the private sector, health professional bodies, consumer groups, academics, the research community and other non-governmental bodies in addressing risk factors, the need to adopt a life-course perspective on chronic disease prevention, and the need to diminish inequalities in society by focusing on the poorest communities and population groups. Strategic actions recommended by the WHO for promoting healthy diets and physical activity include carrying out ongoing nutrition surveillance, providing effective communication of information about food composition and quality, applying strict codes of practice in food labelling and advertising, encouraging intersectoral alliances to ensure that healthy diet components are available and affordable to all, and providing adequate training about diet, nutrition and physical activity to all health professionals. Approaches to promoting healthier diets and lifestyles in the Republic of Ireland should follow these principles.

There are a number of limitations to the present study. As mentioned earlier, food balance sheets overestimate food consumption and nutrient intakes because they fail to take into account food waste or spoilage or other losses that occur after the retail level[49]. Also, they only allow for per capita estimates and lack the information necessary to analyse the population by sex, age and socio-economic status. In addition,

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Table 1. Percentage contributions of protein, fat, carbohydrate (CHO), SFA, MUFA, PUFA and sugars to total energy (% en), excluding alcohol, and per capita supply of NSP and selected micronutrients (per 10 MJ energy) from the present study compared with results from previous national nutrition surveys in Irish adults

Year of study	Reference	Protein (% en)	Fat (% en)	CHO (% en)	SFA (% en)	MUFA (% en)	PUFA (% en)	Sugars (% en)	NSP (g/10 MJ)	Vitamin D (μg/10 MJ)	Vitamin E (mg/10 MJ)	Vitamin B_1 (mg/10 MJ)	Vitamin B_2 (mg/10 MJ)	Vitamin B_6 (mg/10 MJ)	Folate (μg/10 MJ)	Ca (mg/10 MJ)	Fe (mg/10 MJ)
1990	Present study	15·7	34·9	49·4	13·4	10·5	5·7	19·9	34·0	1·66	11·3	2·51	1·91	n/a	349	789	13·6
	Lee & Cunningham (1990)[15]	15·3	36·4	48·3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1194	13·1
1997–9	Present study	16·1	35·7	48·2	14·6	11·4	5·8	17·8	31·4	1·82	10·9	2·49	1·98	3·53	345	797	13·1
	Harrington *et al.* (2001)[62], Hannon *et al.* (2001)[70], O'Brien *et al.* (2001)[72]	16·4	37·0	46·6	14·0	12·0	7·0	16·1	22·4	4·23	12·4	2·46	2·31	4·08	329	927	16·2
1998	Present study	16·1	35·7	48·2	14·6	10·6	5·3	17·2	31·5	1·85	10·4	2·47	1·97	3·53	349	798	13·1
	Friel *et al.* (1999)[35]	15·8	35·6	48·5	n/a	n/a	n/a	n/a	n/a	3·56	9·2	2·03	2·03	3·15	343	948	13·2
2002	Present study	17·3	34·2	48·5	13·6	10·3	5·3	17·9	33·2	2·07	11·0	2·66	2·13	3·74	376	869	13·9
	Kelleher *et al.* (2003)[37]	16·8	35·6	47·5	n/a	n/a	n/a	n/a	n/a	3·44	10·0	2·13	2·33	3·24	373	1017	13·6
2007	Present study	16·5	35·5	48·0	13·0	12·0	7·1	17·4	35·1	1·95	13·4	2·63	1·93	3·62	381	803	14·1
	Morgan *et al.* (2008)[16]	17·0	36·0	47·0	13·0	12·0	7·0	n/a	n/a	3·78	9·4	2·20	2·20	3·36	371	1021	14·0

n/a, Not available.

the present results for micronutrients are limited by the fact that food balance sheets provide no information on either bioavailability or fortification. For these reasons, it is not possible to make direct comparisons between data derived from food balance sheets and those from food consumption surveys because each approach measures different levels of dietary information. To try to overcome this limitation and facilitate at least some sort of comparison, we presented our data in relative terms (for example, as percentage of total energy, as ratios, or per 10 MJ energy, as appropriate). Another limitation of food balance sheets is that foods are listed as basic commodities rather than the specific products that individuals eat. This presents a challenge as regards how to code the data properly for nutritional analysis. For consistency, we coded at the level of the raw unprocessed commodity wherever possible; however, we acknowledge that this could lead to an overestimation of some components, for example, fibre. Another important limitation is the lack of detail regarding certain commodities, such as types of fish, fruits and vegetables. To try to overcome this issue we populated these categories using information about commonly consumed foods from a QFFQ developed specifically for an Irish population. Although this could only give an approximation of true supply for these categories it ensured that foods typically consumed in the Republic of Ireland but which were not already specifically accounted for in the food balance sheets would be represented. Table 1 compares the results for macronutrients and selected micronutrients from the five most recent national nutrition surveys in Ireland with our corresponding results for those same dates. Bearing in mind the above limitations and the different methodologies involved, there was very good agreement on the whole between these two sets of figures, which suggests that the trends in nutrient supply that we have presented here are likely to be a reasonable reflection of what has actually occurred over the past 50 years.

In conclusion, the present study sheds new light on the changes in energy and nutrient supply that have taken place in the Republic of Ireland since the early 1960s. There has been a substantial decrease in the proportion of energy derived from carbohydrates; a corresponding increase in energy from fat and (more recently) alcohol; a reduction in SFA with an overall improvement in the fatty acid profile; and slight reductions in both sugars and fibre. On a nutrient-density basis, vitamins and minerals met or exceeded WHO recommendations, apart from vitamin D, folate, Ca and Fe. Surprisingly, considering the dramatic increase in obesity rates that has occurred within the last 20 years, there was little evidence of any increase in per capita energy supply over the same period. The imbalances that currently exist in the Irish food supply, especially in relation to fat and carbohydrates but also with regard to certain micronutrients, became established or were already evident several decades ago; for this reason they will not be resolved easily or quickly. It would appear that major public health nutrition initiatives will be needed to bring the Irish diet into line with WHO recommendations for the prevention of chronic disease.

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T. S. and S. S. conceived and designed the study. T. S. collated and analysed the data and drafted the manuscript. S. S. critically reviewed the manuscript and contributed to its revision.

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Appendix 1. Commodities listed in FAO food balance sheets

Cereals – excluding beer: wheat; rice (milled equivalent); barley; maize; rye; oats; millet; sorghum; cereals (other)
Starchy roots: cassava; potatoes; sweet potatoes; yams; roots (other)
Sugar crops: sugar cane; sugar (raw equivalent); sweeteners (other); honey
Pulses: beans; peas; pulses (other); treenuts
Oilcrops: soyabeans; groundnuts (shelled equivalent); sunflower seed; rape and mustard seed; coconuts – including copra; sesame seed; olives; oilcrops (other)
Vegetable oils: soyabean oil; groundnut oil; sunflower seed oil; rape and mustard oil; cottonseed oil; palm oil; coconut oil; sesame seed oil; olive oil; maize germ oil; oilcrops oil (other)
Vegetables: tomatoes; onions; vegetables (other)
Fruits – excluding wine: oranges; lemons; grapefruit; citrus (other); bananas; plantains; apples; pineapples; dates; grapes; fruits (other)
Stimulants: coffee; cocoa beans; tea
Spices: pepper; pimento; cloves; spices (other)
Alcoholic beverages: wine; beer; beverages (fermented); beverages (alcoholic)
Meat: bovine meat; mutton and goat meat; pig meat; poultry meat; meat (other); offals (edible)
Animal fats: butter, ghee; cream; animal fats (raw); fish body oil; fish liver oil
Milk – excluding butter
Eggs
Fish, seafood: freshwater fish: demersal fish; pelagic fish; marine fish; other
Crustaceans: cephalopods; molluscs, other
Miscellaneous

Appendix 2. Recommended nutrient intakes[80]

Nutrient	Female (age 19–50 years)	Male (age 19–50 years)	Mean
Ca (mg)	1000	1000	1000
Mg (mg)	220	260	240
Fe (mg) – assuming 15 % bioavailability	19·6	9·1	14·4
Zn (mg) – assuming moderate bioavailability	4·9	7	6
Se (μg)	26	34	30
Iodine (μg)	150	150	150
Vitamin A (μg retinol equivalents)	500	600	550
Vitamin D (μg)	5	5	5
Vitamin E (mg α-tocopherol equivalents)	7·5	10	8·75
Thiamin (mg)	1·1	1·2	1·15
Riboflavin (mg)	1·1	1·3	1·2
Niacin (mg niacin equivalents)	14	16	15
Vitamin B_6 (mg)	1·3	1·3	1·3
Vitamin B_{12} (μg)	2·4	2·4	2·4
Folate (μg dietary folate equivalents)	400	400	400
Vitamin C (mg)	45	45	45