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ORIGINAL ARTICLE

Cancer incidence in Ireland—the possible role of diet, nutrition and lifestyle

Daniel M. A. McCartney[1] · **Declan G. Byrne**[2,3] · **Marie M. Cantwell**[4] · **Michael J. Turner**[5]

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Abstract
Aim This observational ecological study aims to compare Ireland's age-specific cancer incidence rates (ASRs) with equivalent European and global data and to highlight possible dietary, nutritional and lifestyle contributors to cancer in Ireland.
Subjects and methods Using the International Agency for Research on Cancer's (IARC) GLOBOCAN database, Irish ASRs for all-site cancer and for "lifestyle-related" cancers such as those of the colo-rectum, oesophagus, breast, lung and prostate were compared with European and global incidence data. Irish dietary and nutrient intake data were reviewed and evaluated in the context of these cancer incidence data and in relation to the established dietary, nutritional, lifestyle and anthropometric predictors of increased cancer risk previously articulated in the literature.
Results Incidence rates of colorectal, oesophageal, breast, lung, prostate and all-site cancer are higher in Ireland than in most other countries. National nutrition surveys in Ireland indicate that dietary, nutritional, lifestyle and anthropometric risk factors for cancer occur with high frequency in the Irish population. For example, low fruit and vegetable consumption, high red and processed meat intake, low fish intake, low dairy consumption, high saturated fat intake, low folate and vitamin D intakes, and excessive alcohol consumption are all common amongst Irish adults.
Conclusions Our data suggest that unfavourable diet and nutrient intakes prevail in Ireland and that these may contribute to Ireland's excess cancer burden. These risk factors should be targeted by interventions seeking to sustainably redress Ireland's high cancer incidence. Such initiatives may provide a template for intervention in other high-risk countries.

Keywords Cancer · Diet · Nutrients · Obesity · Ireland

Background

Incidence

Statistics from the International Agency for Research on Cancer's (IARC) 2008 GLOBOCAN database revealed Ireland's age-specific incidence rate (ASR) for all-site cancer to be amongst the highest in the world (GLOBOCAN 2008). In 2008, 356 per 100,000 of the Irish male population were diagnosed with cancer, third only behind France and Australia. Among females, 285 per 100,000 of the population were diagnosed with cancer that year, placing Irish women third highest in the world after Denmark and New Zealand. When both sexes were considered together, Ireland ranked a close second highest in the world behind Denmark in 2008, with 317 cancer diagnoses per 100,000 of the population. To put these data into context, the average yearly age-specific cancer incidence globally at that time was 182 per 100,000, 204 per 100,000 for men and 165 per 100,000 for women. These data indicate that overall, cancer

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incidence rates were 75 % higher amongst Irish men and 73 % higher amongst Irish women than the average global figures in 2008, with colo-rectal, breast, lung, prostate, oesophageal, liver and pancreatic cancers particularly prevalent (Ferlay et al. 2010).

Follow-up analysis of the 2012 GLOBOCAN database incorporating data from 184 nations (GLOBOCAN 2012) suggests that while some progress has been made in terms of Ireland's absolute ASR, cancer incidence remains higher than that experienced in most other countries. In 2012, the all-site cancer ASR for Irish men was 343 per 100,000 placing them 11th highest in the world, while for Irish women, the equivalent figure was 279 per 100,000 placing them 6th highest in the world. The all-site cancer ASR for the overall population was 308 per 100,000, placing Ireland sixth highest globally. It is noteworthy that for many "lifestyle-related" cancers [i.e. those related to diet, physical inactivity, smoking, alcohol consumption and anthropometric status (McKenzie et al. 2016)], such as those of the colo-rectum, breast, prostate, oesophagus and lung; Ireland continues to fare particularly poorly (Ferlay et al. 2013). For example, based on the GLOBOCAN 2012 data, Ireland ranked 14th highest in the world for colo-rectal cancer (13th highest for men, 14th highest for women), 8th highest for breast cancer and 9th highest for prostate cancer, as well as having the third highest incidence of oesophageal cancer among the 28 EU-member states (3rd highest for men, 2nd highest for women).

Overall, the 2012 GLOBOCAN data indicate that the top five lifestyle-related cancers (oesophageal, colo-rectal, lung, breast and prostate) account for approximately half of the all-site cancer ASR across the EU-28, reaffirming their previously identified role as key drivers of overall cancer burden (Arnold et al. 2016). For Ireland, the GLOBOCAN data show that the cumulative contribution of these five cancers to all-site cancer ASR is even greater however, exceeding that observed globally, across the EU-28, and even for countries with notably high all-site cancer incidences such as France and Denmark. This suggests that Ireland's sixth place global ranking for all-site cancer is reflective of its relatively high incidence of all of these major cancers combined, and to the significant degree to which Ireland's individual ASRs for some of these common cancers (particularly prostate cancer) exceed those observed elsewhere. Comparative ASR data for selected lifestyle-related cancers are shown for Ireland, the 28 EU-member states and the world in Table 1; while Table 2 provides data describing the proportion of all-site cancer ASR attributable to the five major lifestyle-related cancers in Ireland and other high incidence territories (France, Denmark and the UK).

In comparison to average global figures, the most recent Irish data from GLOBOCAN 2012 indicate all-site cancer incidence rates which are now 67 % higher amongst Irish men and 69 % higher amongst Irish women than their respective global averages. Even in comparison to the 50 countries and regions with the highest overall cancer incidence monitored by GLOBOCAN, these analyses put Irish all-site cancer incidence 6.5 % higher in

Table 1 Comparative ASR data for lifestyle-related cancers for Ireland, the EU-28 and World (IARC GLOBOCAN 2012)

Cancer site	ICD code	Overall population					Males					Females				
		Ireland (ASR/ 100,000)	EU-28 (ASR/ 100,000)	World (ASR/ 100,000)	Ireland ranking vs. EU-28	Ireland ranking globally	Ireland (ASR/ 100,000)	EU-28 (ASR/ 100,000)	World (ASR/ 100,000)	Ireland ranking vs. EU-28	Ireland ranking globally	Ireland (ASR/ 100,000)	EU-28 (ASR/ 100,000)	World (ASR/ 100,000)	Ireland ranking vs. EU-28	Ireland ranking globally
All sites	C00-97/C44	308	271	182	3	6	343	311	205	7	11	279	241	165	4	6
Breast	C50											92.3	80.3	43.1	5	8
Colo-rectum	C18-21	34.9	31.3	17.2	8	14	43.1	39.5	20.6	10	13	27.7	24.4	14.3	6	14
Lung	C33-34	31.3	30.5	23.1	11	24	36.1	45.1	34.2	24	48	27.4	18.2	13.6	4	7
Oesophagus	C15	5.7	3.4	5.9	3	32	8.4	5.8	9.0	3	33	3.2	1.4	3.1	2	39
Ovary	C56											11.2	9.4	6.1	9	14
Pancreas	C25	6.6	7.0	4.2	19	32	7.4	8.2	4.9	20	39	5.9	5.9	3.6	14	24
Prostate	C61						114.2	70.4	30.6	2	9					
Uterus	C54											11.1	9.6	8.2	22	60

Table 2 Proportion of all-site cancer ASR attributable to the five major lifestyle-related cancers in Ireland and other high incidence territories

Cancer site	World ASR	Sex-adjusted World ASR*	Ireland ASR	Sex-adjusted Ireland ASR*	France ASR	Sex-adjusted France ASR*	Denmark ASR	Sex-adjusted Denmark ASR*	UK ASR	Sex-adjusted UK ASR*	EU-28 ASR	Sex–adjusted EU-28 ASR*
All site	182	182	307.9	307.9	303.5	303.5	338.1	338.1	272.9	272.9	271	271
Breast	43.1	21.6	92.3	46.2	89.7	44.9	105	52.5	95	47.5	80.3	40.2
Colo-rectum	17.2	17.2	34.9	34.9	30	30	40.5	40.5	30.2	30.2	31.3	31.3
Lung	23.1	23.1	31.3	31.3	35	35	39.2	39.2	30	30	30.5	30.5
Oesophagus	5.9	5.9	5.7	5.7	3.8	3.8	3.9	3.9	6.5	6.5	3.4	3.4
Prostate	30.6	15.3	114.2	57.1	98	49	91.3	45.7	73.2	36.6	70.4	35.2
Lifestyle-related ASR	119.9	83.1	278.4	175.2	256.5	162.7	279.9	181.8	234.9	150.8	215.9	140.6
% Lifestyle related	65.9	45.7	90.4	56.9	84.5	53.6	82.8	53.8	86.1	55.3	79.7	51.9

*For sex-adjusted ASRs, the gender-specific ASRs for breast and prostate cancer from GLOBOCAN (2012) have been halved as a crude estimate of their contribution to cumulative lifestyle-related cancer risk across both genders

men and 10.2 % higher in women than the respective average figures for these high incidence territories.

In relation to other European countries, Ireland also compares unfavourably. For example, in 2012 the all-site cancer ASRs for the EU-28 were 271 per 100,000 for the overall population, 311 per 100,000 for men and 241 per 100,000 for women. These estimates place incidence rates amongst Irish men 10.3 % higher, and rates amongst Irish women 15.8 % higher, than those observed in other EU countries, with a preponderance of lifestyle-related cancers contributing most of this excess cancer burden as shown in Table 2. Furthermore, Ireland's overall cancer burden has been projected to rise exponentially over coming years, with incidence rates set to climb by 72 % by 2030, a significantly greater increase than that anticipated for any of the other 27 EU-member states (World Cancer Research Fund UK 2012). The National Cancer Registry of Ireland (NCRI) has estimated that excluding non-melanoma skin cancer, overall cancer incidence (i.e. cancer incidence unadjusted for age) will increase by 81 % for females and by 108 % for males by 2040, based on demographic changes alone. Should the adverse trends in incidence observed between 1994 and 2010 continue however, the expected increase in incidence by 2040 will be 48–112 % for Irish females and 114 %–128 % for Irish males. Again, increases in the incidence of lifestyle-related cancers such as those of the colo-rectum (~120–130 %), oesophagus (>100 %), pancreas (>100 %), breast (130 %), prostate (104 %) and lung (136 %) are projected to be the most pronounced (National Cancer Registry 2014).

Mortality

While age-specific cancer incidence has remained high in Ireland, Irish mortality rates from most cancers have fallen substantially in recent years. For example, amongst Irish men, age-specific mortality from all-site cancer ranked 31st highest out of 40 European countries surveyed in 2012, although age-specific mortality for Irish women still ranked ninth highest out of these 40 countries (Ferlay et al. 2013). Recent data indicate that falling cancer mortality in Ireland has been primarily driven by enhanced remedial intervention for those diagnosed with cancer, rather than by cancer prevention however. For example, significant improvements in Irish survival rates from cancer of the stomach (29 %), colon (15 %), rectum (17 %), liver (88 %), lung (36 %), breast (9 %), ovary (15 %), prostate (27 %) and childhood (7 %) and adult leukaemias (19 %) were achieved between 1995 and 2009 (Allemani et al. 2015).

Epidemiological predictors of cancer

Internationally, there is now substantial epidemiological evidence that a poor quality diet, high alcohol intake, physical inactivity and overweight and obesity are potent risk factors for multiple malignancies (Vineis and Wild 2014), with an

increasing number of candidate food and nutrient effectors identified in recent years (Zanini et al. 2015; Song et al. 2015). In 2007, the World Cancer Research Fund/American Institute for Cancer Research Second Expert Report on Food, Nutrition, Physical Activity, and the Prevention of Cancer comprehensively articulated the dietary, nutritional, lifestyle and anthropometric factors that had been associated with cancer risk to that date (World Cancer Research Fund/American Institute for Cancer Research 2007). These findings are summarised in Table 3.

In the period since 2007, the World Cancer Research Fund through its Continuous Update Project and others have continued to review and augment the evidence regarding diet, physical activity and cancer risk (also shown in Table 3). In examining these dietary, nutritional, lifestyle and anthropometric predictors of cancer risk, there is now strong evidence from large prospective cohort studies (Bradbury et al. 2014; Oyebode et al. 2014), case-control studies (Turati et al. 2015) and meta-analyses (Aune et al. 2012a; Liu and Lv 2013; Wang et al. 2015) that low fruit and vegetable intakes are associated with increased risk of cancer at multiple sites including the mouth, oesophagus, stomach, pancreas, colo-rectum, larynx, lung, kidney, breast and ovary; with low fruit and vegetable consumption estimated to play a role in 5–12 % of preventable cancers overall (Vainio and Weiderpass 2006). Prospective studies and meta-analyses have also shown an association between low dietary fibre intakes and increased risk of breast (Dong et al. 2011a), colo-rectal (Murphy et al. 2012) and oesophageal (Coleman et al. 2013) malignancy, further highlighting the importance of these high fibre foods.

In relation to proteinaceous foods, high red meat and processed red meat intakes have been consistently associated with increased risk of colo-rectal (Chan et al. 2011; Aune et al. 2013; Ananthakrishnan et al. 2015) and oesophageal (Salehi et al. 2013; Qu et al. 2013; Huang et al. 2013; Zhu et al. 2014) cancer, as well as an increased risk of lung (Yang et al. 2012; Xue et al. 2014) and breast (Guo et al. 2015) cancer. Evidence has also emerged of increased all-site cancer incidence and mortality among those with higher red and processed meat intakes (Bouvard et al. 2015; Pan et al. 2012), with several mutagenic mechanisms now suggested to explain these proposed carcinogenic effects (Abid et al. 2014; Bouvard et al. 2015). In contrast to the data concerning red and processed meat intakes, a number of meta-analyses (Shen et al. 2012; Zheng et al. 2013; Jiang et al. 2016; Yu et al. 2014; Huang et al. 2015) and prospective cohort studies (Farvid et al. 2014) have associated higher fish consumption with reduced risk of several cancers, including those of the oesophagus, liver, colo-rectum and breast, with plausible mechanisms for these putative protective effects also beginning to emerge (DiNicolantonio et al. 2014). The relationship between dairy foods and cancer risk appears more complicated however. While recent systematic reviews and meta-analyses have generally supported an inverse relationship between milk and dairy intake and cancers of the colo-rectum, bladder and breast (Lampe 2011; Dong et al. 2011b; Aune et al. 2012b; Abid et al. 2014), these same studies and others (Aune et al. 2014) have identified an increased risk of prostate cancer in men with higher milk and dairy intakes.

With regard to macronutrient intakes, high saturated fat intake has been associated with increased colo-rectal cancer risk (Levi et al. 2002) and increased mortality from breast cancer (Brennan et al. 2015). Conversely, high omega-3 (*n*3 fish oil) intake has been inversely associated with risk of several malignancies (Pauwels and Kairemo 2008), although biomarker data have not always supported this association (Alexander et al. 2015).

In relation to individual micronutrient intakes, several case-control (Tavani et al. 2012; Sharp et al. 2013), prospective cohort (Bassett et al. 2013; de Batlle et al. 2014) and meta-analysis (Lin et al. 2013; Tio et al. 2014) studies have identified a higher risk of oro-pharyngeal, oesophageal, pancreatic, colo-rectal and breast cancer in those with low folate intakes, especially where these deficits coincide with high alcohol consumption (Giovannucci 2004; Nishihara et al. 2014). Recent evidence has also failed to substantiate earlier suggestions of increased gut cancer risk with folic acid supplementation (Mason 2009; Vollset et al. 2013), lending further support to the potential benefits of higher folate intake.

Notwithstanding some evidence of increased bladder cancer risk at high calcium intakes (Brinkman et al. 2011), low calcium intake (Peterlik et al. 2009) and especially poor vitamin D status (Grant et al. 2007; Giovannucci 2009; Touvier et al. 2011) have been implicated in colo-rectal, breast and other cancers. In relation to vitamin D, several meta-analyses (Wei et al. 2008; Mohr et al. 2011; Ma et al. 2011; Yin et al. 2013) and reviews of observational, ecological and case-control studies (Holick 2013; Giovannucci 2013; Grant 2014, 2015) since 2007 have suggested an association between higher intakes and blood levels of vitamin D and reduced risk of colo-rectal, pancreatic, breast and ovarian cancer.

From the lifestyle perspective, there is now convincing evidence that high alcohol intake (more than 4 drinks per day) increases the risk of oro-pharyngeal cancer (by 500 %), laryngeal cancer (by 250 %), colo-rectal cancer (by 50 %), breast cancer (by 50 %) and pancreatic cancer (by 30 %) (Pelucchi et al. 2011). Subsequent large prospective studies (Schütze et al. 2011; Romieu et al. 2015), meta-analyses (Bagnardi et al. 2015) and reviews (Scoccianti et al. 2015a) have also implicated high alcohol consumption as a potent risk factor for cancers of the oro-pharynx, larynx, breast, oesophagus, stomach, colo-rectum, liver, gallbladder, pancreas, prostate and lung, as well as for all-site cancer. One recent retrospective, observational study has estimated that in Ireland between 2001 and 2010, 4.7 % of all cancer incidence in men and 4.2 % of all cancer incidence in women was attributable to the over-consumption of alcohol (Laffoy et al. 2013).

Table 3 Research evidence linking foods, nutrients, lifestyle factors and anthropometry with cancer risk

Food, nutrient or lifestyle factor	Directionality of risk	Types of malignancy	Strength of evidence up to 2007 (WCRF/AICR 2007)	Subsequent evidence	Nature of subsequent evidence (after 2007)	Directionality of risk
Fruit	Reduced	Mouth, pharynx, larynx Naso-pharynx **Oesophagus** **Lung** Stomach Pancreas Liver **Colo-rectum**	Suggestive to probable	Aune et al. 2012a Bradbury et al. 2014 Wang et al. 2015 Turati et al. 2015	Systematic review and meta-analysis of prospective studies Review of 20 published studies from the EPIC prospective cohort study (n >500,000 participants) investigating fruit, vegetable and dietary fibre intake and cancer risk Dose-response meta-analysis of 16 prospective cohort studies (n = 15,421 cases among 1,791,469 subjects) examining fruit intake and lung cancer risk Review of multicentre, case-control studies (n = >10,000 ca cases, >17,000 controls) investigating the association between fruit and vegetable consumption and cancer risk at multiple sites	↓ RR for breast cancer (0.89 for fruit and veg, 0.92 for fruit alone—highest v lowest intake) ↓ lung and upper GI cancer risk with higher fruit intake ↓ RR for lung cancer (0.84 for highest vs. lowest intake groups). 5 % reduction in risk per extra fruit serving/d up to 2 servings/d Cancer ORs for the highest vs. lowest quintile of fruit intake: 0.39 (oro-pharyngeal), 0.52 (oesophageal), 0.53 (stomach), 0.72 (colo-rectal), 0.60 (pancreatic), 0.52 (laryngeal)
Non-starchy vegetables	Reduced	Mouth, pharynx, larynx Naso-pharynx **Oesophagus** **Lung** Stomach Liver **Colo-rectum** Ovary Endometrium	Suggestive to probable	Liu and Lv 2013 Oyebode et al. 2014 Wang et al. 2015 Turati et al. 2015	Meta-analysis of 11 case-control and 2 prospective cohort studies (cruciferous vegetables) Prospective mortality data in the Health Survey for England Study (n = 65,226) Dose-response meta-analysis of 19 studies (n = 16,422 cases among 1,877,375 subjects) examining vegetable intake and lung cancer risk Review of multicentre, case-control studies (n = >10,000 cancer cases, >17,000 controls) investigating the association between fruit and vegetable consumption and cancer risk at multiple sites	↓ RR for breast cancer (0.85 in highest vs. lowest consumers of cruciferous vegetables ↓ HR for all-site cancer mortality (0.75) and overall mortality (0.67) for 7+ portions/d vs. <1 portion/d of fruit and vegetables ↓ RR for lung cancer (0.90 for highest vs. lowest intake groups). 3 % reduction in risk per extra veg serving/d up to 2 servings/d Cancer ORs for the highest vs. lowest quintile of vegetable intake: 0.19 (oro-pharyngeal), 0.51 (naso-pharyngeal), 0.32 (oesophageal), 0.47 (stomach), 0.57 (colo-rectal), 0.72 (liver), 0.66 (pancreatic), 0.17 (laryngeal), 0.73 (breast), 0.59 (endometrial), 0.47 (ovarian), 0.65 (kidney), 0.49 (non-Hodgkin's lymphoma)
Milk	Reduced	**Colo-rectum** Bladder	Suggestive to probable	Lampe 2011 Aune et al. 2012a Abid et al. 2014 Aune et al. 2014	Review of meta-analyses undertaken since 2007 examining milk and calcium intake and cancer risk Systematic review and meta-analysis of 19 cohort studies (n = 11,579 cases, 1,170,942 subjects) investigating the association between dairy intake and colorectal cancer Summary review of National Cancer Institute Studies post-2007 (meat, dairy foods and cancer) WCRF CUP systematic review and meta-analysis of 32 cohort studies up to Apr 2013 investigating dairy and calcium intake and prostate cancer risk	High milk and dairy intakes ↓ colo-rectal and bladder cancer risk, but ↑ prostate ca risk ↓ RR for colo-rectal cancer (0.83 per 400 g/d dairy foods, 0.91 per 200 g/d of milk and 0.96 per 50 g/d of cheese) High dairy and calcium intakes ↓ colo-rectal, bladder and breast cancer risk, but may ↑ prostate cancer risk ↑ RR for prostate cancer (1.07 per 400 g/d dairy foods, 1.03 per 200 g/d of milk, 1.06 per 200 g/d low fat milk, 1.09 per 50 g/d of cheese, 1.05 per 400 mg/d dietary calcium)
Dietary fibre	Reduced	**Oesophagus** **Colo-rectum**	Suggestive to probable	Dong et al. 2011a Murphy et al. 2012 Coleman et al. 2013	Meta-analysis of 10 prospective cohort studies (n = 16,848 cases; 712,195 participants) International prospective study (EPIC) (n = 4,517 cases, 477,312 participants) after mean follow-up of 11 years Systematic review and meta-analysis of 10 case-control studies (8 for oesophageal adenoCa) investigating links between oesophageal cancer and dietary fibre intake	↓ RR for breast cancer (0.89) for highest vs. lowest fibre consumers. 7 % ↓ in breast cancer risk for each 10 g/d ↑ in fibre intake ↓ HR for colo-rectal cancer (0.87 per 10 g/d increase in dietary fibre intake) ↓ OR for oesophageal adenocarcinoma (0.66) for highest vs. lowest fibre consumers
Foods containing folate	Reduced	**Oesophagus** Pancreas **Colo-rectum** **Breast**	Suggestive to probable	Sharp et al. 2013 Tio et al. 2014 Lin et al. 2013 Song et al. 2015	Population-based, case-control study (n = 223 cases and 256 controls) investigating dietary folate intakes and risk of oesophageal adenoCa and Barrett's oesophagus	↓ OR for oesophageal adenocarcinoma (0.56 for highest vs. lowest dietary folate intakes) ↓ ORs for oesophageal (0.59) and pancreatic (0.66) cancer in highest vs. lowest folate intake groups

Table 3 (continued)

Food, nutrient or lifestyle factor	Directionality of risk	Types of malignancy	Strength of evidence up to 2007 (WCRF/AICR 2007)	Subsequent evidence	Nature of subsequent evidence (after 2007)	Directionality of risk
				Bassett et al. 2013 de Batlle et al. 2014 Tavani et al. 2012	Systematic review and meta-analysis of 9 retrospective studies investigating the role of folate in oesophageal Ca, and 8 studies investigating the role of folate in pancreatic Ca Meta-analysis and dose-response meta-analysis of 6 cohort- and 4 case-control studies Review article of B-vitamins and other foods and nutrients in colo-rectal cancer risk, including putative anti-carcinogenic mechanisms for folate Prospective cohort study ($n = 910$ cases among 37,112 participants over 15 years of follow-up) investigating B vitamin and methionine intakes and colo-rectal cancer risk International prospective study (EPIC) ($n = 11,575$ cases, 367,993 participants; followed up over 11 years) in relation to dietary folate and breast cancer risk. Multi-centre case control study ($n = 8,573$ cases; 22,828 controls over 18 years)	↓ OR for pancreatic cancer (0.66) in the highest vs. lowest dietary folate intake group Adequate folate ↓ colo-rectal cancer risk ↓ OR for colo-rectal cancer (0.63) with high folate, low methionine diet ↓ OR for pre-menopausal breast cancer risk (0.66-0.70). 14 % reduction in breast cancer risk in highest vs. lowest dietary folate tertiles in women with high alcohol intake (>12 drinks/week) ↓ ORs for oropharyngeal (0.65), oesophageal (0.58), colo-rectal (0.83), pancreatic (0.72), laryngeal (0.67) and breast (0.87) cancer per 100 μg/day increment in dietary folate
Foods containing vitamin D	Reduced	**Colo-rectum**	Suggestive	Wei et al. 2008 Mohr et al. 2011 Yin et al. 2013 Ma et al. 2011 Holick 2013 Giovannucci 2013 Grant 2014 Grant 2015	Meta-analysis (1 cross-sectional, 9 case-control, and 7 cohort/nested case-control studies) investigating vitamin D intakes and levels in relation to colo-rectal cancer risk Analysis of pooled data from 11 case-control studies on serum 25(OH)D vs. breast Ca Meta-analysis with random effects models - cancer incidence and mortality (18 studies) Systematic review and meta-analysis of 18 prospective studies; 9 on vitamin D intake and 9 on 25(OH)D levels, in relation to colo-rectal Ca ($n = \sim 1,000,000$ participants) Review of studies implicating vitamin D deficiency in increased all-site cancer risk Review of observational studies examining the role of vitamin D levels in risk of incident colo-rectal cancer, and in cancer progression and mortality Review of ecological and observational studies; application of Hill's causality criteria to assess the role of vitamin D in 15 cancers Review of 11 case-control studies in 7 countries (serum 25(OH)D and breast cancer)	↓ OR for colo-rectal adenoma (0.70) in high versus low circulating 25(OH)D. Highest quintile of vitamin D intake had 11 % lower risk of colorectal adenomas vs. lowest intake ↓ OR for breast cancer (0.61) in the highest vs. lowest serum 25(OH)D groups. Serum 25(OH)D level of ≥47 ng/ml had a 50 % lower risk of breast cancer ↓ RRs for all-site cancer incidence (0.89) and cancer mortality (0.83) with a 50 nmol/l increase in serum 25(OH)D levels ↓ OR for colo-rectal cancer in highest vs. lowest intake group (0.88) and in highest vs. lowest serum 25(OH)D group (0.67) ↓ risk of colo-rectal, breast, pancreas, ovarian cancer with serum 25(OH)D levels of 100-150 nmol/l Adequate vitamin D levels ↓ the risk of colo-rectal cancer, and of its progression and mortality from it. Adequate vitamin D levels are causally associated with ↓ colo-rectal and breast cancer risk, and possibly ↓ risk of others ↓ breast cancer risk (case-control studies) and colo-rectal cancer risk (nested case-controls) with adequate serum 25(OH)D
Fish	Reduced	**Colo-rectum**	Suggestive	Shen et al. 2012 Zheng et al. 2013 Jiang et al. 2016 Yu et al. 2014 Farvid et al. 2014 DiNicolantonio et al. 2014 Huang et al. 2015	Meta-analysis of 7 prospective cohort studies ($n = 489,465$ participants; 4,656 cases) investigating $n3$ fatty acid intake and colo-rectal cancer risk Meta-analysis of 21 prospective cohort studies (11 for fish intake; $n = 13,323$ cases and 687,770 participants; 17 for marine $n3$ PUFA intake; $n = 16,178$ cases and 527,392 participants) Meta-analysis of observational studies (17 case-control; 3 cohort; $n = 3,990$ cases)	↓ OR for colo-rectal cancer risk in men (0.87) with higher $n3$ PUFA intakes ↓ OR for breast cancer risk (0.86) in highest vs. lowest marine $n3$ PUFA intake and tissue level groups. Risk of breast cancer ↓ 5 % per 0.1 g/d increase in marine $n3$ PUFA intake ↓ OR for oesophageal squamous cell carcinoma (0.69) in highest vs. lowest fish consumers ↓ OR for GI cancers (oesophageal, liver, colo-rectal) in regular (0.93), moderate (0.94) and high (0.91) fish consumers vs. non-/infrequent consumers.

Table 3 (continued)

Food, nutrient or lifestyle factor	Directionality of risk	Types of malignancy	Strength of evidence up to 2007 (WCRF/AICR 2007)	Subsequent evidence	Nature of subsequent evidence (after 2007)	Directionality of risk
					investigating the association between fish intake and oesophageal cancer	2 % reduced risk of GI cancer per 20 g/d increase in fish intake
					Meta-analysis of 42 cohort studies (n = 2,325,040 participants, 24,115 GI cancer cases; average follow-up of 13.6 years)	↓ OR (0.86) for breast cancer by substituting one serving of red meat per day with fish, poultry, nuts and legumes combined
					Prospective cohort study (Nurse's Health Study; n = 88,803 participants; 2,830 cases over 20 years follow-up) investigating fish intake and breast cancer risk	Dietary EPA/DHA plausibly ↓ risk of adenocarcinoma by a no. of mechanisms
					Review of studies describing the COX-2 mediated anti-cancer effects of EPA and DHA on adenocarcinoma development	↓ ORs for liver cancer in highest vs. lowest total fish intake groups in case-control (0.79) and cohort (0.82) studies. Increased fish intake of 1 serving per week yielded a 6 % lower risk of liver cancer
					Meta-analysis of 5 retrospective and 5 prospective cohort studies (n = 3,624 cases)	
Red and processed meats	Increased	**Oesophagus** **Lung** Stomach Pancreas **Colo-rectum** Endometrium Prostate	Suggestive to convincing	Chan et al. 2011 Pan et al. 2012 Yang et al. 2012 Aune et al. 2013 Salehi et al. 2013 Qu et al. 2013 Huang et al. 2013 Zhu et al. 2014 Xue et al. 2014 Ananthakrishnan et al. 2015 Guo et al. 2015 Bouvard et al. 2015	Meta-analysis of 24 prospective studies (10 after 2007) including 19 cohort studies investigating the association between red and processed meat intakes and colo-rectal cancer	↑ OR of colo-rectal cancer (1.22) in highest vs. lowest red and processed meat intake gp. RRs for colo-rectal Ca of 1.18 (per 100 g/d red meat) and 1.17 (per 50 g/d proc meat).
					Combined Health Professionals Follow-up Study (n = 37,698) and Nurses' Health Study (n = 83,644) prospective investigation of red and processed meat intake and cancer death (n = 9,464 cancer deaths) over 2.96 million person years of follow-up	↑ HRs for cancer death for red meat (1.10) and processed meat (1.16) per serving/d
						↑ OR for lung cancer in highest vs. lowest intake groups for total meat (1.35), red meat (1.34) and processed meat (1.06)
					Systematic review and meta-analysis of 11 cohort and 23 case-control studies investigating meat intake and lung cancer incidence (n = 1,797,402)	↑ RR for colo-rectal adenoma: per 100 g/d red meat: 1.27 (all studies), 1.20 (prospective studies), 1.34 (case-controls); per 50 g/d processed meat: 1.29 (all studies), 1.45 (prospective studies), 1.23 (case-controls)
					WCRF CUP systematic review and meta-analysis of 7 prospective and 19 case-control studies up to Dec 2011 investigating red meat and processed meat intakes and colo-rectal adenoma risk.	↑ RR for oesophageal cancer (1.40) in highest vs. lowest red meat intake group; and of 1.41 in highest vs. lowest processed meat intake group
					Systematic review and meta-analysis of 4 cohort and 31 case-control studies from 1990–2011 investigating meat and fish intakes and oesophageal cancer risk	↑ OR for oesophageal squamous cell carcinoma in highest vs. lowest red meat (1.57) and processed meat (1.55) consumers
					Meta-analysis of 19 case-control and 2 cohort studies investigating red and processed meat intake and oesophageal squamous cell carcinoma risk (n = 6,499 cases of squamous cell carcinoma)	↑ RR for oesophageal adenoma in highest vs. lowest red meat (1.31) and processed meat (1.41) consumers. ↑ RRs of 1.45 per 100 g/d red meat; 1.37 per 50 g/day of proc meat.
					Meta-analysis of observational studies (3 cohort and 7 case-control studies) up to May 2012 examining red and processed meat intake and oesophageal adenocarcinoma risk	↑ RR for oesophageal cancer in highest vs. lowest red meat (1.55) and processed meat (1.33) consumers. ↑ red meat intake assoc with oesophageal squamous cell carcinoma; ↑ proc meat intake with adenocarcinoma.
					Systematic review and meta-analysis of 7 cohort; 28 case-control studies up to April 2013 investigating red meat and processed meat intake and oesophageal cancer risk	↑ RR for lung cancer for highest vs. lowest red meat (1.44) and processed meat (1.23) intakes; 35 % ↑ in risk per 120g/d red meat; 20 % ↑ in risk per 50 g/d processed meat.
					Dose-response meta-analysis of 6 cohort and 28 case-control studies up to June 2013 investigating red and processed meat intake and lung cancer risk	↑ OR for colo-rectal cancer for highest vs. lowest red meat consumers (1.41) (from retrospective data examined only).
					Meta-analysis of 11 case-control studies (n = 8,290 colo-rectal cancer cases; 9,115 controls)	↑ OR for breast cancer for highest vs. lowest red meat (1.10) and processed meat (1.08) consumers; ↑ RR of 1.11 per 120 g/d red meat and 1.09 per 50 g/d processed meat

Table 3 (continued)

Food, nutrient or lifestyle factor	Directionality of risk	Types of malignancy	Strength of evidence up to 2007 (WCRF/AICR 2007)	Subsequent evidence	Nature of subsequent evidence (after 2007)	Directionality of risk
					Dose-response meta-analysis of 14 prospective studies ($n = 31,552$ breast cancer cases) up to Oct 2014 examining red and processed meat intake and breast cancer risk IARC Expert Working Group; >800 studies examining red and processed meat intakes and cancer risk	↑ colorectal and stomach cancer risk with increasing processed meat intake; ↑ colorectal, pancreatic and prostate cancer risk with increasing red meat intake
Alcohol	Increased	Mouth, pharynx, larynx **Oesophagus** Liver **Colo-rectum** **Breast** Kidney	Probable to convincing (suggestive for kidney)	Pelucchi et al. 2011 Schütze et al. 2011 Laffoy et al. 2013 Romieu et al. 2015 Scoccianti et al. 2015a Bagnardi et al. 2015	Review of studies examining alcohol intake vs. cancer at multiple sites EPIC prospective cohort in 8 EU countries ($n = 109,118$ men; 254,870 women, aged 37–70 years) Review of national hospital and cancer mortality records in Ireland (2001–10) EPIC prospective cohort (10 EU countries; $n = 334,850$ women, 11,576 cases breast Ca) Review of alcohol consumption and its implication for cancer incidence in Europe Dose-response meta-analysis (572 studies, 486,538 cancer cases, 23 cancer types)	20–500 % ↑ risk: mouth, pharynx, larynx, oesophagus, breast, colo-rectum, pancreas 10 % (men) and 3 % (women) of all cancer incidence attributable to alcohol 4.7 % (men) and 4.2 % (women) of all cancer incidence attributable to alcohol ↑ HR by 4.2 % per 10 g/d ↑ in alcohol intake ↑ dose-dependent Ca risk: mouth, pharynx, larynx, oesophagus, liver, colorectum, breast RRs for high vs. no/occasional alcohol consumption: mouth and pharynx (5.13), larynx (2.65), breast (1.61), oesophagus (4.95), stomach (1.21), colo-rectum (1.44), liver (2.07), gallbladder (2.64), pancreas (1.19), prostate, lung (1.15)
Physical activity	Reduced	**Lung** Pancreas **Colo-rectum** **Breast** Endometrium	Suggestive to probable (convincing for colo-rectum)	Lee et al. 2012 Singh et al. 2014 Brenner 2014	Modelling study: global population attributable fraction (PAFs) for ↓ physical activity and colon and breast cancer Systematic review and meta-analysis of 4 cohort and 5 case-control studies ($n = 1,871$ cases of oesophageal cancer among 1,381,844 patients) Modelling study: Canadian population attributable fraction (PAFs) for ↓ physical activity and cancer at multiple sites	Low physical activity causes 10 % of breast cancer and 10 % of colon cancer globally 32 % lower risk of oesophageal adenoCa in highest vs. lowest physical activity group 7.9 % of colon, breast, endometrial, prostate, lung, and ovarian cancer combined attributable to low physical activity
Body fatness	Increased	**Oesophagus** Pancreas Gall-bladder Liver **Colo-rectum** **Breast (post-menopausal)** Endometrium Kidney	Probable to convincing (suggestive for liver)	Abnet et al. 2008 Ning et al. 2010 Gaudet et al. 2014 Ligibel et al. 2014 Arnold et al. 2015 Byers and Sedjo 2015	US NIH-AARP Diet and Health study ($n = 480,475$; 287,960 men, 192,515 women) Meta-analysis and meta-regression analysis of 56 observational studies ($n = 7,213,335$ individuals including 93,812 colorectal cancer cases) Cancer Prevention Study-II ($n = 28,965$ postmenopausal women; 1,088 breast cancer cases on median follow-up of 11.6 years) American Society of Clinical Oncology Position Statement on Obesity and Cancer Modelling study using PAFs calculated from international GLOBOCAN data. Review of different mechanisms by which excessive adiposity contributes to cancer risk including excessive androgens, inflammation, excess leptin, insulin and IGFs and immunosuppression	BMI ≥35 kg/m^2 associated with ↑er risk of oesophageal adenoCa (HR 2.27) and gastric cardia adenoCa (HR 2.46) vs. BMI 18.5–25 Compared with BMI <23.0 kg/m^2, BMI of 23.0–24.9, 25.0–27.4, 27.5–29.9 and ≥30.0 kg/m^2 associated with 14 %, 19 %, 24 % and 41 % increased risks of colorectal Ca. 18 % ↑ in risk per 5 kg/m^2 ↑ in BMI ↑ in HR of 1.13 per 10 cm ↑ in waist circumference, explained by effect of larger waist on BMI (HR ↑ by 1.04 per 1 kg/m^2) Obesity increases cancer risk and worsens cancer prognosis at multiple sites (e.g. breast, colon, prostate) 481,000 (3.6 %) of all new global cancer cases in adults >30 years are attributable to high BMI. Uterine, post-menopausal breast and colon cancers account for 63.6 % of cancers attributable to high BMI Excess adiposity is associated with increased breast, ovarian, oesophageal, liver, colorectal, pancreatic, prostate, kidney and gallbladder cancer

Table 3 (continued)

Food, nutrient or lifestyle factor	Directionality of risk	Types of malignancy	Strength of evidence up to 2007 (WCRF/AICR 2007)	Subsequent evidence	Nature of subsequent evidence (after 2007)	Directionality of risk
Central obesity	Increased	Pancreas **Colo-rectum** **Breast (post-menopausal)** Endometrium	Probable to convincing	Ryan et al. 2011 Doyle et al. 2012 Singh et al. 2013 Ma et al. 2013 Riondino et al. 2014 Chan and Norat 2015	Systematic review of epidemiological studies (2005–2010) and mechanistic studies linking obesity and oesophageal adenocarcinoma Review of mechanistic studies linking visceral obesity and breast, colorectal and oesophageal cancer Systematic review and meta-analysis of 40 studies investigating central adiposity and oesophagitis, Barrett's oesophagus and oesophageal adenocarcinoma (6 studies) Systematic review and meta-analysis of studies investigating the links between obesity (41 studies; $n = 8,115,689$ participants, 85,935 cases) and central obesity (13 studies; $n = 817,449$ participants, 6,546 cases) and colorectal cancer risk Review of the mechanistic associations between central obesity, pro-inflammatory and other adipokines and colorectal cancer risk Review of evidence linking obesity and central obesity to pre- and postmenopausal breast cancer risk and survival	↑risk from obesity, central obesity and its associated inflammation and insulin resistance ↑risk of visceral obesity from inflammation, insulin resistance and altered IGF-1 ↑ adjusted OR (2.51) for adenoCa in centrally obese vs. lowest waist meas group ↑ RRs for obese (BMI > 30 kg/m^2) vs. normal BMI (1.33) and for the highest vs. lowest waist circumference group (1.46) Pro-inflammatory adipokines and hormones (e.g. adiponectin, leptin, resistin and ghrelin) implicated in colorectal carcinogenesis Obesity and central obesity increase breast cancer risk and adversely affect pt survival
Lactation	Reduced	**Breast (pre- and post-menopausal)** Ovary	Convincing (suggestive for ovary)	Scoccianti et al. 2015b Zhou et al. 2015 Luan et al. 2013 Li et al. 2014	Review of epidemiological and biological studies investigating breastfeeding and breast cancer risk Meta-analysis of 27 studies ($n = 13,907$ cases) investigating the association between breastfeeding and breast cancer risk Meta-analysis of 5 prospective and 30 case-control studies up to Dec 2012 ($n = 14,465$ cases and 706,152 non-cases) investigating breastfeeding and ovarian cancer risk Systematic review and meta-analysis of 5 cohort and 35 case-control studies ($n = 17,139$ cases and 398,810 non-cases) investigating breastfeeding and ovarian cancer risk	2 % reduction in breast cancer risk per 5 months increase in breastfeeding duration RR of 0.61 for ever vs. never breastfeeders; RR of 0.47 for longest vs. shortest breastfeeding duration RR of 0.76 for ever vs. never breastfeeders, 8 % reduction in ovarian cancer risk per 5 months increase in breastfeeding duration RR of 0.70 for ever vs. never breastfeeders; RRs for breastfeeding duration: 0.85 (<6 mths); 0.73 (6–12 mths); 0.64 (>12 mths)

OR odds ratio, *HR* hazard ratio, *RR* relative risk

[a] Cancers occurring with high frequency in Ireland (colo-rectal, oesophageal, lung, breast and prostate) highlighted in bold

In relation to other lifestyle behaviours, several modelling (Lee et al. 2012; Brenner 2014), epidemiological (Friedenreich et al. 2010) and meta-analysis (Singh et al. 2014) studies have identified physical inactivity as an independent risk factor for oesophageal, colo-rectal, breast, ovarian, endometrial, prostatic and lung cancer. There is also considerable evidence from experimental (Doyle et al. 2012; Riondino et al. 2014; Byers and Sedjo 2015), prospective cohort (Abnet et al. 2008; Gaudet et al. 2014), modelling (Renehan et al. 2010; Arnold et al. 2015), meta-analysis (Ning et al. 2010; Singh et al. 2013; Ma et al. 2013) and review (Ryan et al. 2011; Chan and Norat 2015) studies that overweight and obesity, the anthropometric manifestations of poor diet and physical inactivity; and the diabetes and metabolic syndrome which frequently accompany them (Braun et al. 2011), significantly increase the risk of many cancers including those of the oesophagus, liver, pancreas, gallbladder, colo-rectum, kidney, breast, ovary, uterus and prostate. Finally, in relation to infant feeding practices amongst women, there is now convincing evidence from review (Scoccianti et al. 2015b) and systematic review and meta-analysis studies (Luan et al. 2013; Li et al. 2014; Zhou et al. 2015) of a dose-related reduction in risk of breast cancer amongst women who have breastfed.

Overall, epidemiological data from the UK (Parkin et al. 2011) suggest that 9.2 % of all cancers are attributable to poor diet (low fruit and vegetable, high red meat, low dietary fibre and high salt intakes). A further 5.5 % of cases are thought to relate to overweight and obesity, with an additional 4.4 % ascribed to the effects of alcohol overconsumption. These findings are supported by other recent international data (Vineis and Wild 2014; Zanini et al. 2015; Wirth et al. 2015) emphasising the importance of diet and lifestyle in determining overall cancer risk.

The Irish perspective

In the Irish context, the 1996 report *Cancer Services in Ireland: A National Strategy* (Department of Health and Children 1996) outlined some of the key areas in which the Irish diet could be improved in relation to cancer risk (e.g. the consumption of more fruit and vegetables, more dietary fibre, less fat and less alcohol). However, this document did not explicate how these objectives were to be achieved on a population basis. In 2006, *A Strategy for Cancer Control in Ireland* (National Cancer Forum 2006) highlighted the need to "raise awareness of the links between diet and cancer" and stated the potential healthcare savings that could accrue from developing such a preventative approach. Unfortunately however, recent research suggests that awareness of the links between cancer and poor diet, and between cancer and obesity, remains limited among Irish adults, with just 76 % and 32 % of respondents respectively citing these issues as risk factors for the disease (Ryan et al. 2015).

Diet and lifestyle patterns in Ireland

Despite the potential of healthy diet and lifestyle to ameliorate Ireland's cancer burden, the National Adult Nutrition Survey (NANS) (Walton 2011), as well as other national diet and lifestyle surveys (Morgan et al. 2008), suggest that nutritional risk factors for cancer abound in the Irish population. Average milk and dairy intakes are estimated at less than two of the recommended three servings per day (National Dairy Council 2013), while fish and omega-3 intakes are also very low (Leite et al. 2010). Intakes of red and processed meats are high however (Cosgrove et al. 2005), while salt consumption (a known accelerant in the generation of meat-related carcinogens such as nitrosamines, heterocyclic aromatic amines and polycyclic-aromatic hydrocarbons) remains elevated (Walton 2011; Lin et al. 2015). The importance of these high red meat intakes is further highlighted by data from Irish adults which show a greater than three-fold higher risk of oesophageal adenocarcinoma amongst those in the highest quartile of fresh red meat intake versus those in the lowest quartile (O'Doherty et al. 2011).

Critically, mean fruit and vegetable intakes in Ireland are also less than half of the 400 g per day recommended by the World Health Organisation (Walton 2011). This is of concern as fruit and vegetables are a primary source of antioxidants, which may be important in the prevention of some cancers (La Vecchia et al. 2013; Chen et al. 2016). One all-Ireland population-based, case-control study showed that those in the lowest overall antioxidant index category (a measure of combined vitamin C, vitamin E, total carotenoid and selenium intake) were almost twice as likely to develop oesophageal adenocarcinoma as those in the highest intake category, while those in the lowest vitamin C intake category were over two and a half times more likely to develop the condition than those in the highest intake category (Murphy et al. 2010). As alluded to previously, these prevailing low intakes of fruit and vegetables are also pertinent in the context of dietary fibre consumption, where just 20 % of the Irish adult population has been shown to reach the European Food Safety Authority's recommended intake of 25 g/day (Walton 2011).

From a macronutrient intake perspective, 63 % of Irish adults exceed the recommended 35 % of food energy from total fat (Walton 2011), while saturated fat intakes in Ireland are estimated to be roughly 30–35 % higher than recommended (O'Keeffe et al. 2013). In one Irish study, those in the highest quartile of total fat intake had a five-fold increased risk of developing oesophageal adenocarcinoma compared with those in the lowest intake quartile, while those in the highest saturated fat intake quartile were more than twice as

likely to develop the condition as those in the lowest intake quartile (O'Doherty et al. 2011).

With regard to individual micronutrient intakes, despite the contribution made by voluntary food fortification, dietary vitamin D intakes in Ireland remain low (Black et al. 2014, 2015). Indeed, there is now compelling evidence of endemic vitamin D insufficiency across the Irish population (Cashman et al. 2013), while inadequate calcium intakes are observed in ~8 % of Irish women (Hennessy et al. 2014). In relation to folate, while roughly 4 % of the overall adult population has intakes below the estimated average requirement, low intake and sub-optimal folate status are even more prevalent amongst younger women (Hopkins et al. 2015). Previous research in Irish adults has shown that risk of oesophageal adenocarcinoma increases proportionately with declining folate intake (Sharp et al. 2013), further emphasising the importance of this micronutrient intake deficit.

In Ireland, all of these nutritional shortcomings are superimposed on a collage of deleterious health behaviours. Overall, one-third of male drinkers and over one-fifth (22.8 %) of female drinkers consume alcohol at intakes exceeding the low-risk weekly consumption guidelines (i.e. less than 16.8 standard drinks per week for men and 11.2 standard drinks for women). Among younger male consumers (43.8 %) and younger female consumers (39.0 %), intakes above these weekly guidelines are especially common. Binge pattern consumption is also prevalent, with almost two-fifths (37.3 %) of all respondents consuming six or more standard drinks on a single occasion once per month and one-in-five drinkers (21.1 %) engaged in binge drinking at least once a week. Again, monthly binge drinking is most common among males aged 18–24 years (67.8 %), with one in four young men (27.9 %) and more than one in five young women (22.5 %) exceeding the recommended weekly intake guidelines on one single day in the week prior to the reference survey (Long and Mongan 2014).

It has been estimated that in Ireland between 2001 and 2010, 4585 diagnoses (4.7 %) of invasive cancer in males and 4593 diagnoses (4.2 %) of invasive cancer in females were attributable to alcohol, with 53 % of upper aerodigestive tract cancers in males and 35.2 % of these cancers in females related to excessive drinking. Overall, alcohol accounted for 6.7 % of male cancer deaths and 4.6 % of female cancer deaths during this 10-year period, with roughly 900 new cancers and 500 cancer deaths per year directly attributable to its effects (Laffoy et al. 2013).

In relation to physical activity, the SLAN study revealed that 45 % of Irish adults were insufficiently active, with 19 % reporting no habitual physical activity at all (Morgan et al. 2008), supporting previous research which had indicated significantly lower activity levels in Ireland than in most other European countries (Sjöström et al. 2006). These findings have more recently been corroborated by an analysis of WHO data which showed that Irish adults had the seventh lowest physical activity levels out of 36 European countries surveyed (Hallal et al. 2012). Fifty-three percent of Irish adults in this study reported that they did not achieve the recommended weekly activity guideline [5 × 30 min episodes of moderate intensity activity (e.g. walking) or 3 × 20 min bursts of vigorous activity, or a combination of the two) on a weekly basis. In terms of the explicit cancer burden imposed by physical inactivity, it has been estimated that 15.7 % of colorectal cancer cases and 15.2 % of breast cancer cases in Ireland are attributable to physical inactivity, a considerably greater proportion than the 10 % of these malignancies thought to be due to low physical activity on a global basis (Lee et al. 2012). In relation to infant feeding practices, despite modest improvements in recent years, Irish women continue to have amongst the lowest breastfeeding rates in the world (Nolan and Layte 2015).

Perhaps unsurprisingly, the prevalence of overweight and obesity in Ireland has increased substantially over the past three decades (Boylan et al. 2014) and is now considerably higher than that observed in most other EU member states. Ireland currently ranks third highest for overweight and obesity combined amongst men (2nd highest for obesity alone) and ninth highest amongst women (10th highest for obesity alone) among the 28 EU-member states (World Obesity Federation 2015). In global terms, Ireland ranks 19th highest for obesity among men and 57th highest for obesity among women (International Association for the Study of Obesity 2015).

There is emerging evidence of the deleterious impact that these obesity rates are having on Ireland's rates of diabetes and on the overall metabolic health of the nation. In 2013, the prevalence of diabetes in Irish adults was estimated at 6.5 %, with 207,500 people suffering from the condition, and 1568 deaths annually directly attributable to its effects (International Diabetes Federation 2013). This is relevant as metabolic syndrome and type II diabetes are important risk factors for cancer (Deng et al. 2012; Luo et al. 2016). Overall, if current trends continue, it has been estimated that Ireland's prevalence of obesity-related cancers will increase by 34 % between 2010 and 2020 and by 61 % between 2010 and 2030 (Keaver et al. 2013).

Conclusions and recommendations

The data presented here show that Ireland has a high incidence of all-site and especially lifestyle-related cancers relative to other countries and that this situation is worsening. Notwithstanding the often observational or correlative nature of evidence linking food and nutrient intakes with cancer, as well as the ecological nature of the current study, the behavioural and other data presented here do suggest that poor diet and lifestyle may be contributing to Ireland's high cancer rates (Institute for Health Metrics and Evaluation 2013;

Organisation for Economic Cooperation and Development 2015). There are also ecological data from other countries with high cancer incidence which support a contributory role of poor diet, high alcohol intake and obesity in increased cancer risk. For example, low intakes of fruit and vegetables, fish and breakfast cereals, and high intakes of red and processed meats and alcohol have been reported among Danish adults, with these deficits coinciding with high intakes of saturated fat and low intakes of vitamin D (Knudsen et al. 2012). These findings have been echoed by a recent EPIC study which identified low dietary quality scores amongst Danish adults (Lassale et al. 2016). In France, historic data have similarly shown low fruit and vegetable and high saturated fat intakes (Volatier and Verger 1999), with recent studies suggesting the persistence of these low fruit and vegetable intakes (Francou et al. 2015) and of low wholegrain food intakes (Bellisle et al. 2014). While the prevalence of obesity in Denmark (14.2 %) and France (14.5 %) is considerably lower than that observed in Ireland (23.0 %), both France and Denmark have low to moderate physical activity levels (Loyen et al. 2016), and at a yearly consumption of 12–15 l per capita aged 15 years and over, both have excessive alcohol intakes, which are reflected in higher alcohol-attributable all-cause mortality rates than the EU average or those recorded for Ireland (Anderson et al. 2012).

Although the dietary, nutritional, lifestyle and anthropometric deficits described for Ireland are prevalent among all strata of Irish society, there is now clear evidence that they are both more common and more pronounced among those of low socio-economic status (Layte and Whelan 2009; McCartney et al. 2013; Madden 2013), a group whose incidence of (Donnelly et al. 2013) and mortality from (Balanda and Wilde 2001; Donnelly and Gavin 2010) all-site cancer are considerably greater than those of their more affluent peers. While international data also suggest higher cancer incidence and mortality rates (Merletti et al. 2011) and less favourable food and nutrient intakes (Nikolić et al. 2014) amongst those of low socio-economic status, the contributory role of poor diet and nutrient intakes to social inequalities in cancer risk is yet to be fully articulated.

The 2006 *Strategy for Cancer Control in Ireland* has rightly stated that knowledge enhancement alone will be insufficient to promote the dietary changes required to reduce cancer risk among the Irish public. While enhanced public awareness of the dietary and lifestyle risk factors for cancer is required (Laffoy et al. 2013; Ryan et al. 2015), complementary policy responses in relation to these population behavioural patterns are also needed. For example, there is emerging international evidence which suggests that food taxation and subsidy initiatives could yield substantial advantages in addressing Ireland's high overall prevalence of chronic disease (Ni Mhurchu et al. 2015). In Ireland itself, it has been estimated that over half of alcohol-related cancers would be prevented by population adherence to Department of Health alcohol consumption guidelines (Laffoy et al. 2013). In terms of food intake, while modelling studies have suggested that population-wide improvements in diet might reduce cardiovascular disease in Ireland by 10 to 26 % (O'Keeffe et al. 2013), the overlap between these "heart healthy" dietary regimens and those associated with reduced cancer risk (Steck et al. 2015) implies that a further consequential benefit would also arise in relation to the latter.

In summary, prioritisation of diet and lifestyle interventions in the prevention of cancer has the potential to yield a considerable public health dividend in Ireland and other high-risk countries. Strengthening national nutrition and health behavioural surveillance systems would allow greater insight into cancer-promoting dietary and lifestyle choices as well as the spatial, ecological and socio-demographic factors which underpin them (Ligibel et al. 2014). By using such data, more effective preventative strategies could be developed to redress the unsustainable cancer incidence trends that are now emerging in Ireland.

Compliance with ethical standards

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Research involving human participants and/or animals This review article references five studies with human participants or animals performed by the authors:

One study undertaken by the lead author Daniel McCartney:

McCartney DM, Younger KM, Walsh J et al. (2013) Socio-economic differences in food group and nutrient intakes among young women in Ireland. Br J Nutr. 110:2084–97. doi: 10.1017/S0007114513001463).

All procedures involving human participants in this study were carried out in accordance with the ethical standards of the Dublin Institute of Technology Research Ethics Committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Formal ethical approval for this study was granted by the Dublin Institute of Technology Research Ethics Committee in 2005.

Four studies undertaken by co-author Marie Cantwell:

Brennan SF, Woodside JV, Lunny PM, Cardwell CR, Cantwell MM (2015) Dietary fat and breast cancer mortality: a systematic review and meta-analysis. Crit Rev Food Sci Nutr. 2015 Feb 18. [Epub ahead of print]—accessed 26th February 2016.

Murphy SJ, Anderson LA, Ferguson HR, Johnston BT, Watson PR, McGuigan J, Comber H, Reynolds JV, Murray LJ, Cantwell MM (2010) Dietary antioxidant and mineral intake in humans is associated with reduced risk of esophageal adenocarcinoma but not reflux esophagitis or Barrett's esophagus. J Nutr. 140:1757–63.

O'Doherty MG, Cantwell MM, Murray LJ, Anderson LA, Abnet CC; FINBAR Study Group (2011) Dietary fat and meat intakes and risk of reflux esophagitis, Barrett's esophagus and esophageal adenocarcinoma. Int J Cancer. 129:1493–502. doi: 10.1002/ijc.26108.

Sharp L, Carsin AE, Cantwell MM, Anderson LA, Murray LJ FINBAR Study Group (2013). Intakes of dietary folate and other B vitamins are associated with risks of esophageal adenocarcinoma, Barrett's esophagus, and reflux esophagitis. J Nutr. 143:1966–73. doi: 10.3945/jn.113.174664.

All procedures involving human participants in these studies were carried out in accordance with the ethical standards of the Queens University Belfast Research Ethics Committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Formal ethical approval for these studies was granted by the Queens University Belfast Research Ethics Committee.

References

Abid Z, Cross AJ, Sinha R (2014) Meat, dairy, and cancer. Am J Clin Nutr 100(Suppl 1):386S–393S. doi:10.3945/ajcn.113.071597

Abnet CC, Freedman ND, Hollenbeck AR, Fraumeni JF Jr, Leitzmann M, Schatzkin A (2008) A prospective study of BMI and risk of oesophageal and gastric adenocarcinoma. Eur J Cancer 44:465–471. doi:10.1016/j.ejca.2007.12.009

Alexander DD, Bassett JK, Weed DL, Barrett EC, Watson H, Harris W (2015) Meta-analysis of long-chain omega-3 polyunsaturated fatty acids (LCω-3PUFA) and prostate cancer. Nutr Cancer 67:543–554. doi:10.1080/01635581.2015.1015745

Allemani C, Weir HK, Carreira H, Harewood R, Spika D, Wang XS, Bannon F, Ahn JV, Johnson CJ, Bonaventure A, Marcos-Gragera R, Stiller C, Azevedo e Silva G, Chen WQ, Ogunbiyi OJ, Rachet B, Soeberg MJ, You H, Matsuda T, Bielska-Lasota M, Storm H, Tucker TC, Coleman MP, CONCORD Working Group (2015) Global surveillance of cancer survival 1995–2009: analysis of individual data for 25,676,887 patients from 279 population-based registries in 67 countries (CONCORD-2). Lancet 385:977–1010. doi:10.1016/S0140-6736(14)62038-9

Ananthakrishnan AN, Du M, Berndt SI, Brenner H, Caan BJ, Casey G, Chang-Claude J, Duggan D, Fuchs CS, Gallinger S, Giovannucci EL, Harrison TA, Hayes RB, Hoffmeister M, Hopper JL, Hou L, Hsu L, Jenkins MA, Kraft P, Ma J, Nan H, Newcomb PA, Ogino S, Potter JD, Seminara D, Slattery ML, Thornquist M, White E, Wu K, Peters U, Chan AT (2015) Red meat intake, NAT2, and risk of colorectal cancer: a pooled analysis of 11 studies. Cancer Epidemiol Biomarkers Prev 24:198–205. doi: 10.1158/1055-9965.EPI-14-0897

Anderson P, Moller L, Galea G (2012) Alcohol in the European Union - consumption, harm and policy approaches. World Health Organisation, Geneva. http://www.euro.who.int/__data/assets/pdf_file/0003/160680/e96457.pdf. Accessed 27 September 2016

Arnold M, Pandeya N, Byrnes G, Renehan AG, Stevens GA, Ezzati M, Ferlay J, Miranda JJ, Romieu I, Dikshit R, Forman D, Soerjomataram I (2015) Global burden of cancer attributable to high body-mass index in 2012: a population-based study. Lancet Oncol 16:36–46. doi:10.1016/S1470-2045(14)71123-4

Arnold M, Rentería E, Conway DI, Bray F, Van Ourti T, Soerjomataram I (2016) Inequalities in cancer incidence and mortality across medium to highly developed countries in the twenty-first century. Cancer Causes Control 27:999–1007. doi:10.1007/s10552-016-0777-7

Aune D, Chan DS, Vieira AR, Rosenblatt DA, Vieira R, Greenwood DC, Norat T (2012a) Fruits, vegetables and breast cancer risk: a systematic review and meta-analysis of prospective studies. Breast Cancer Res Treat 134:479–493. doi:10.1007/s10549-012-2118-1

Aune D, Lau R, Chan DS, Vieira R, Greenwood DC, Kampman E, Norat T (2012b) Dairy products and colorectal cancer risk: a systematic review and meta-analysis of cohort studies. Ann Oncol 23:37–45

Aune D, Chan DS, Vieira AR, Navarro Rosenblatt DA, Vieira R, Greenwood DC, Kampman E, Norat T (2013) Red and processed meat intake and risk of colorectal adenomas: a systematic review and meta-analysis of epidemiological studies. Cancer Causes Control 24:611–627. doi:10.1007/s10552-012-0139-z

Aune D, Navarro Rosenblatt DA, Chan DS, Vieira AR, Vieira R, Greenwood DC, Vatten LJ, Norat T (2014) Dairy products, calcium, and prostate cancer risk: a systematic review and meta-analysis of cohort studies. Am J Clin Nutr 101:87–117. doi:10.3945/ajcn.113.067157

Bagnardi V, Rota M, Botteri E, Tramacere I, Islami F, Fedirko V, Scotti L, Jenab M, Turati F, Pasquali E, Pelucchi C, Galeone C, Bellocco R, Negri E, Corrao G, Boffetta P, La Vecchia C (2015) Alcohol consumption and site-specific cancer risk: a comprehensive dose–response meta-analysis. Br J Cancer 112:580–593. doi:10.1038/bjc.2014.579

Balanda K, Wilde J (2001) Inequalities in mortality: a report on all-Ireland mortality data 1989–1998. Institute of Public Health in Ireland, Dublin. http://www.publichealth.ie/sites/default/files/documents/files/Inequalities%20in%20Mortality.pdf. Accessed 27 September 2016

Bassett JK, Severi G, Hodge AM, Baglietto L, Hopper JL, English DR, Giles GG (2013) Dietary intake of B vitamins and methionine and colorectal cancer risk. Nutr Cancer 65:659–667. doi:10.1080/01635581.2013.789114

Bellisle F, Hébel P, Colin J, Reyé B, Hopkins S (2014) Consumption of whole grains in French children, adolescents and adults. Br J Nutr 112:1674–1684. doi:10.1017/S0007114514002670

Black LJ, Walton J, Flynn A, Kiely M (2014) Adequacy of vitamin D intakes in children and teenagers from the base diet, fortified foods and supplements. Public Health Nutr 17:721–731. doi:10.1017/S1368980013000359

Black LJ, Walton J, Flynn A, Cashman KD, Kiely M (2015) Small increments in vitamin D intake by Irish adults over a decade show that strategic initiatives to fortify the food supply are needed. J Nutr 145:969–976. doi:10.3945/jn.114.209106

Bouvard V, Loomis D, Guyton KZ, Grosse Y, Ghissassi FE, Benbrahim-Tallaa L, Guha N, Mattock H, Straif K, on behalf of the International Agency for Research on Cancer Monograph Working Group (2015) Carcinogenicity of consumption of red and processed meat. Lancet Oncol 16(16):1599–1600. doi:10.1016/S1470-2045(15)00444-1

Boylan EA, McNulty BA, Walton J, Flynn A, Nugent AP, Gibney MJ (2014) The prevalence and trends in overweight and obesity in Irish adults between 1990 and 2011. Public Health Nutr 17:2389–2397. doi:10.1017/S1368980014000536

Bradbury KE, Appleby PN, Key TJ (2014) Fruit, vegetable, and fiber intake in relation to cancer risk: findings from the European prospective investigation into cancer and nutrition (EPIC). Am J Clin Nutr 100(Suppl 1):394S–398S. doi:10.3945/ajcn.113.071357

Braun S, Bitton-Worms K, LeRoith D (2011) The link between the metabolic syndrome and cancer. Int J Biol Sci 7:1003–1015

Brennan SF, Woodside JV, Lunny PM, Cardwell CR, Cantwell MM (2015) Dietary fat and breast cancer mortality: a systematic review and meta-analysis. Crit Rev Food Sci Nutr 18th Feb 2015. doi:10.1080/10408398.2012.724481

Brenner DR (2014) Cancer incidence due to excess body weight and leisure-time physical inactivity in Canada: implications for prevention. Prev Med 66:131–139. doi:10.1016/j.ypmed.2014.06.018

Brinkman MT, Buntinx F, Kellen E, Brinkman MT, Buntinx F, Kellen E (2011) Dietary intake of micronutrients and the risk of developing bladder cancer: results from the Belgian case–control study on bladder cancer risk. Cancer Causes Control 22:469–478. doi:10.1007/s10552-010-9718-z

Byers T, Sedjo RL (2015) Body fatness as a cause of cancer: epidemiologic clues to biologic mechanisms. Endocr Relat Cancer 22:R125–R134. doi:10.1530/ERC-14-0580

Cashman KD, Muldowney S, McNulty B, Nugent A, FitzGerald AP, Kiely M, Walton J, Gibney MJ, Flynn A (2013) Vitamin D status of Irish adults: findings from the national adult nutrition survey. Br J Nutr 109:1248–1256. doi:10.1017/S0007114512003212

Chan DS, Norat T (2015) Obesity and breast cancer: not only a risk factor of the disease. Curr Treat Options Oncol 16:22. doi:10.1007/s11864-015-0341-9

Chan DS, Lau R, Aune D, Vieira R, Greenwood DC, Kampman E, Norat T (2011) Red and processed meat and colorectal cancer incidence: meta-analysis of prospective studies. PLoS One 6, e20456. doi:10.1371/journal.pone.0020456

Chen J, Jiang W, Shao L, Zhong D, Wu Y, Cai J (2016) Association between intake of antioxidants and pancreatic cancer risk: a meta-analysis. Int J Food Sci Nutr 67:744-53. doi:10.1080/09637486.2016.1197892

Coleman HG, Murray LJ, Hicks B (2013) Dietary fiber and the risk of precancerous lesions and cancer of the esophagus: a systematic review and meta-analysis. Nutr Rev 71:474–482. doi:10.1111/nure.12032

Cosgrove M, Flynn A, Kiely M (2005) Consumption of red meat, white meat and processed meat in Irish adults in relation to dietary quality. Br J Nutr 93:933–942

de Batlle J, Ferrari P, Chajes V, Park JY, Slimani N, McKenzie F, Overvad K, Roswall N, Tjønneland A, Boutron-Ruault MC, Clavel-Chapelon F, Fagherazzi G, Katzke V, Kaaks R, Bergmann MM, Trichopoulou A, Lagiou P, Trichopoulos D, Palli D, Sieri S, Panico S, Tumino R, Vineis P, Bueno-de-Mesquita HB, Peeters PH, Hjartåker A, Engeset D, Weiderpass E, Sánchez S, Travier N, Sánchez MJ, Amiano P, Chirlaque MD, Barricarte Gurrea A, Khaw KT, Key TJ, Bradbury KE, Ericson U, Sonestedt E, Van Guelpen B, Schneede J, Riboli E, Romieu I (2014) Dietary folate intake and breast cancer risk: European prospective investigation into cancer and nutrition. J Natl Cancer Inst 107:367. doi:10.1093/jnci/dju367

Deng L, Gui Z, Zhao L, Wang J, Shen L (2012) Diabetes mellitus and the incidence of colorectal cancer: an updated systematic review and meta-analysis. Dig Dis Sci 57:1576–1585. doi:10.1007/s10620-012-2055-1

Department of Health and Children (1996) Cancer services in Ireland: a national strategy 1996. Department of Health and Children, Dublin. http://health.gov.ie/wp-content/uploads/2014/03/cancer_services_strategy1996.pdf. Accessed 2 Mar 2016

DiNicolantonio JJ, McCarty MF, Chatterjee S, Lavie CJ, O'Keefe JH (2014) A higher dietary ratio of long-chain omega-3 to total omega-6 fatty acids for prevention of COX-2-dependent adenocarcinomas. Nutr Cancer 66:1279–1284. doi:10.1080/01635581.2014.956262

Dong JY, He K, Wang P, Qin LQ (2011a) Dietary fiber intake and risk of breast cancer: a meta-analysis of prospective cohort studies. Am J Clin Nutr 94:900–905. doi:10.3945/ajcn.111.015578

Dong JY, Zhang L, He K, Qin LQ (2011b) Dairy consumption and risk of breast cancer: a meta-analysis of prospective cohort studies. Breast Cancer Res Treat 127:23–31. doi:10.1007/s10549-011-1467-5

Donnelly DW, Gavin AT (2010) Trends and patterns in cancer mortality in Northern Ireland. Dublin: J Stat Soc Inq Soc Irel XXXIX:186–210 http://www.tara.tcd.ie/bitstream/handle/2262/41138/donnelly%20and%20gavin%2009-10%20pp186-210.pdf;sequence=1. Accessed 28 July 2016

Donnelly DW, Hegarty A, Sharp L, Carsin AE, Deady S, McCluskey N, Comber H, Gavin A (2013) The impact of adjustment for socioeconomic status on comparisons of cancer incidence between two European countries. J Cancer Epidemiol 2013:612514. doi:10.1155/2013/612514

Doyle SL, Donohoe CL, Lysaght J, Reynolds JV (2012) Visceral obesity, metabolic syndrome, insulin resistance and cancer. Proc Nutr Soc 71:181–189. doi:10.1017/S002966511100320X

Farvid MS, Cho E, Chen WY, Eliassen AH, Willett WC (2014) Dietary protein sources in early adulthood and breast cancer incidence: prospective cohort study. BMJ 348:g3437. doi:10.1136/bmj.g3437

Ferlay J, Shin HR, Bray F, Ferlay J, Shin HR, Bray F (2010) Estimates of worldwide burden of cancer in 2008: GLOBOCAN 2008. Int J Cancer 127:2893–2917. doi:10.1002/ijc.25516

Ferlay J, Steliarova-Foucher E, Lortet-Tieulent J, Rosso S, Coebergh JW, Comber H, Forman D, Bray F (2013) Cancer incidence and mortality patterns in Europe: estimates for 40 countries in 2012. Eur J Cancer 49:1374–1403. doi:10.1016/j.ejca.2012.12.027

Francou A, Hebel P, Braesco V, Drewnowski A (2015) Consumption patterns of fruit and vegetable juices and dietary nutrient density among french children and adults. Nutrients 7:6073–6087. doi:10.3390/nu7085268

Friedenreich CM, Neilson HK, Lynch BM (2010) State of the epidemiological evidence on physical activity and cancer prevention. Eur J Cancer 46:2593–2604. doi:10.1016/j.ejca.2010.07.028

Gaudet MM, Carter BD, Patel AV, Teras LR, Jacobs EJ, Gapstur SM (2014) Waist circumference, body mass index, and postmenopausal breast cancer incidence in the Cancer Prevention Study-II Nutrition Cohort. Cancer Causes Control 25:737–745. doi:10.1007/s10552-014-0376-4

Giovannucci E (2004) Alcohol, one-carbon metabolism, and colorectal cancer: recent insights from molecular studies. J Nutr 134:2475S–2481S

Giovannucci E (2009) Vitamin D and cancer incidence in the Harvard cohorts. Ann Epidemiol 19:84–88. doi:10.1016/j.annepidem.2007.12.002

Giovannucci E (2013) Epidemiology of vitamin D and colorectal cancer. Anticancer Agents Med Chem 13:11–19

GLOBOCAN (2008) Cancer incidence and mortality worldwide database. http://globocan.iarc.fr. Accessed 26 April 2012

GLOBOCAN (2012) Cancer incidence and mortality worldwide database. http://globocan.iarc.fr. Accessed 13 July 2015

Grant WB (2014) Solar ultraviolet irradiance and cancer incidence and mortality. Adv Exp Med Biol 810:52–68

Grant WB (2015) 25-hydroxyvitamin D and breast cancer, colorectal cancer, and colorectal adenomas: case–control versus nested case–control studies. Anticancer Res 35:1153–1160

Grant WB, Garland CF, Gorham ED (2007) An estimate of cancer mortality rate reductions in Europe and the US with 1,000 IU of oral vitamin D per day. Recent Results Cancer Res 174:225–234

Guo J, Wei W, Zhan L (2015) Red and processed meat intake and risk of breast cancer: a meta-analysis of prospective studies. Breast Cancer Res Treat 151:191–198. doi:10.1007/s10549-015-3380-9

Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U, for the Lancet Physical Activity Series Working Group, et al (2012) Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet 380:247–257. doi:10.1016/S0140-6736(12)60646-1

Hennessy A, Hannon EM, Walton J, Flynn A (2014) Impact of voluntary food fortification practices in Ireland: trends in nutrient intakes in Irish adults between 1997–9 and 2008–10. Br J Nutr 113:310–320. doi:10.1017/S0007114514003651

Holick MF (2013) Vitamin D, sunlight and cancer connection. Anticancer Agents Med Chem 13:70–82

Hopkins SM, Gibney MJ, Nugent AP, McNulty H, Molloy AM, Scott JM, Flynn A, Strain JJ, Ward M, Walton J, McNulty BA (2015) Impact of voluntary fortification and supplement use on dietary intakes and biomarker status of folate and vitamin B-12 in Irish adults. Am J Clin Nutr 101:1163–1172. doi:10.3945/ajcn.115.107151

Huang W, Han Y, Xu J, Zhu W, Li Z (2013) Red and processed meat intake and risk of esophageal adenocarcinoma: a meta-analysis of observational studies. Cancer Causes Control 24:193–201. doi:10.1007/s10552-012-0105-9

Huang RX, Duan YY, Hu JA (2015) Fish intake and risk of liver cancer: a meta-analysis. PLoS One 10, e0096102. doi:10.1371/journal.pone.0096102

Institute for Health Metrics and Evaluation (2013) Global burden of disease—country report (Ireland). Institute for Health Metrics and Evaluation, Seattle. http://www.healthdata.org/ireland. Accessed 27 September 2016

International Association for the Study of Obesity (2015) Global prevalence of adult overweight & obesity by region. International Association for the Study of Obesity (IASO), London. http://www.worldobesity.org/site_media/library/resource_images/Global_prevalence_of_Adult_Obesity_17th_June_2015_WO.pdf. Accessed 22 July 2015

International Diabetes Federation (2013) IDF diabetes atlas, 6th edn. International Diabetes Federation, Brussels. http://www.idf.org/diabetesatlas. Accessed 22 July 2015

Jiang G, Li B, Liao X, Zhong C (2016) Poultry and fish intake and risk of esophageal cancer: a meta-analysis of observational studies. Asia Pac J Clin Oncol 12:e82–e91. doi:10.1111/ajco.12114

Keaver L, Webber L, Dee A, Shiely F, Marsh T, Balanda K, Perry IJ (2013) Application of the UK foresight obesity model in Ireland: the health and economic consequences of projected obesity trends in Ireland. PLoS One 8, e79827. doi:10.1371/journal.pone.0079827

Knudsen VK, Fagt S, Trolle E, Matthiessen J, Groth MV, Biltoft-Jensen A, Sørensen MR, Pedersen AN (2012) Evaluation of dietary intake in Danish adults by means of an index based on food-based dietary guidelines. Food Nutr Res 56. doi: 10.3402/fnr.v56i0.17129

La Vecchia C, Decarli A, Serafini M, Parpinel M, Bellocco R, Galeone C, Bosetti C, Zucchetto A, Polesel J, Lagiou P, Negri E, Rossi M (2013) Dietary total antioxidant capacity and colorectal cancer: a large case–control study in Italy. Int J Cancer 133:1447–1451. doi:10.1002/ijc.28133

Laffoy M, McCarthy T, Mullen L, Byrne D, Martin J (2013) Cancer incidence and mortality due to alcohol: an analysis of 10-year data. Ir Med J 106:294–297

Lampe JW (2011) Dairy products and cancer. J Am Coll Nutr 30(Suppl 1):464S–470S

Lassale C, Gunter MJ, Romaguera D, Peelen LM, Van der Schouw YT, Beulens JW, Freisling H, Muller DC, Ferrari P, Huybrechts I, Fagherazzi G, Boutron-Ruault MC, Affret A, Overvad K, Dahm CC, Olsen A, Roswall N, Tsilidis KK, Katzke VA, Kühn T, Buijsse B, Quirós JR, Sánchez-Cantalejo E, Etxezarreta N, Huerta JM, Barricarte A, Bonet C, Khaw KT, Key TJ, Trichopoulou A, Bamia C, Lagiou P, Palli D, Agnoli C, Tumino R, Fasanelli F, Panico S, Bueno-de-Mesquita HB, Boer JM, Sonestedt E, Nilsson LM, Renström F, Weiderpass E, Skeie G, Lund E, Moons KG, Riboli E, Tzoulaki I (2016) Diet quality scores and prediction of all-cause, cardiovascular and cancer mortality in a Pan-European cohort study. PLoS One 11, e0159025. doi:10.1371/journal.pone.0159025, eCollection 2016

Layte R, Whelan CT (2009) Explaining social class inequalities in smoking: the role of education, self-efficacy, and deprivation. Eur Sociol Rev 25:399–410. doi:10.1093/esr/jcn022

Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT, for the Lancet Physical Activity Series Working Group et al (2012) Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet 380:219–229. doi:10.1016/S0140-6736(12)61031-9

Leite JC, Hearty AP, Nugent AP, Gibney MJ (2010) A method for assessing dietary intakes of n-3 long-chain polyunsaturated fatty acids and trans fatty acids in an Irish adult population. Int J Food Sci Nutr 61:583–599. doi:10.3109/09637481003652442

Levi F, Pasche C, Lucchini F, La Vecchia C (2002) Macronutrients and colorectal cancer: a Swiss case–control study. Ann Oncol 13:369–373

Li DP, Du C, Zhang ZM, Li GX, Yu ZF, Wang X, Li PF, Cheng C, Liu YP, Zhao YS (2014) Breastfeeding and ovarian cancer risk: a systematic review and meta-analysis of 40 epidemiological studies. Asian Pac J Cancer Prev 15:4829–4837

Ligibel JA, Alfano CM, Courneya KS, Demark-Wahnefried W, Burger RA, Chlebowski RT, Fabian CJ, Gucalp A, Hershman DL, Hudson MM, Jones LW, Kakarala M, Ness KK, Merrill JK, Wollins DS, Hudis CA (2014) American society of clinical oncology position statement on obesity and cancer. J Clin Oncol 32:3568–3574. doi:10.1200/JCO.2014.58.4680

Lin HL, An QZ, Wang QZ, Liu CX (2013) Folate intake and pancreatic cancer risk: an overall and dose–response meta-analysis. Public Health 127:607–613. doi:10.1016/j.puhe.2013.04.008

Lin S, Wang X, Huang C, Liu X, Zhao J, Yu IT, Christiani DC (2015) Consumption of salted meat and its interactions with alcohol drinking and tobacco smoking on esophageal squamous-cell carcinoma. Int J Cancer 137:582–589. doi:10.1002/ijc.29406

Liu X, Lv K (2013) Cruciferous vegetables intake is inversely associated with risk of breast cancer: a meta-analysis. Breast 22:309–313. doi:10.1016/j.breast.2012.07.013

Long J, Mongan D (2014) Alcohol consumption in Ireland 2013: analysis of a national alcohol diary survey. Health Research Board, Dublin. http://www.hrb.ie/uploads/tx_hrbpublications/Alcohol_Consumption_in_Ireland_2013_web_version.pdf. Accessed 2 March 2016

Loyen A, Van Hecke L, Verloigne M, Hendriksen I, Lakerveld J, Steene-Johannessen J, Vuillemin A, Koster A, Donnelly A, Ekelund U, Deforche B, De Bourdeaudhuij I, Brug J, van der Ploeg HP, DEDIPAC consortium (2016) Variation in population levels of physical activity in European adults according to cross-European studies: a systematic literature review within DEDIPAC. Int J Behav Nutr Phys Act 13:72. doi:10.1186/s12966-016-0398-2

Luan NN, Wu QJ, Gong TT, Vogtmann E, Wang YL, Lin B (2013) Breastfeeding and ovarian cancer risk: a meta-analysis of epidemiologic studies. Am J Clin Nutr 98:1020–1031. doi:10.3945/ajcn.113.062794

Luo S, Li JY, Zhao LN, Yu T, Zhong W, Xia ZS, Shan TD, Ouyang H, Yang HS, Chen QK (2016) Diabetes mellitus increases the risk of colorectal neoplasia: an updated meta-analysis. Clin Res Hepatol Gastroenterol 40:110–123. doi:10.1016/j.clinre.2015.05.021

Ma Y, Zhang P, Wang F, Yang J, Liu Z, Qin H (2011) Association between vitamin D and risk of colorectal cancer: a systematic review of prospective studies. J Clin Oncol 29:3775–3782. doi:10.1200/JCO.2011.35.7566

Ma Y, Yang Y, Wang F, Zhang P, Shi C, Zou Y, Qin H (2013) Obesity and risk of colorectal cancer: a systematic review of prospective studies. PLoS One 8, e53916. doi:10.1371/journal.pone.0053916

Madden D (2013) The socio-economic gradient of obesity in Ireland. Econ Soc Rev (Irel) 44:181–196. http://scholar.google.com/scholar_url?url=http%3A%2F%2Fwww.esr.ie%2Farticle%2Fdownload%2F68%2F59&hl=en&sa=T&oi=ggp&ct=res&cd=0&ei=nKXqV-OyAdS4jAH02JSQDw&scisig=AAGBfm27rjU5QYoaZQhLt9ykuY5MeCG1hA&nossl=1&ws=1440x806. Accessed 27 September 2016

Mason JB (2009) Folate, cancer risk, and the Greek god, Proteus: a tale of two chameleons. Nutr Rev 67:206–212

McCartney DM, Younger KM, Walsh J, O'Neill M, Sheridan C, Kearney JM (2013) Socio-economic differences in food group and nutrient intakes among young women in Ireland. Br J Nutr 110:2084–2097. doi:10.1017/S0007114513001463

McKenzie F, Biessy C, Ferrari P, Freisling H, Rinaldi S, Chajès V, Dahm CC, Overvad K, Dossus L, Lagiou P, Trichopoulos D, Trichopoulou A, Bueno-de-Mesquita HB, May A, Peeters PH, Weiderpass E, Sanchez MJ, Navarro C, Ardanaz E, Ericson U, Wirfält E, Travis RC, Romieu I (2016) Healthy lifestyle and risk of cancer in the European prospective investigation into cancer and nutrition cohort study. Medicine (Baltimore) 95, e2850. doi:10.1097/MD.0000000000002850

Merletti F, Galassi C, Spadea T (2011) The socioeconomic determinants of cancer. Environ Health 10(Suppl 1):S7. doi:10.1186/1476-069X-10-S1-S7

Mohr SB, Gorham ED, Alcaraz JE, Kane CJ, Macera CA, Parsons JK, Wingard DL, Garland CF (2011) Serum 25-hydroxyvitamin D and prevention of breast cancer: pooled analysis. Anticancer Res 31:2939–2948

Morgan K, McGee H, Watson D et al (2008) SLÁN 2007: survey of lifestyle, attitudes & nutrition in Ireland. Main Report. Department of Health and Children, Dublin. https://aran.library.nuigalway.ie/bitstream/handle/10379/5227/SLAN_07_Main_Report.pdf?sequence=1&isAllowed=y. Accessed 2 March 2016

Murphy SJ, Anderson LA, Ferguson HR, Johnston BT, Watson PR, McGuigan J, Comber H, Reynolds JV, Murray LJ, Cantwell MM (2010) Dietary antioxidant and mineral intake in humans is associated with reduced risk of esophageal adenocarcinoma but not reflux esophagitis or Barrett's esophagus. J Nutr 140:1757–1763

Murphy N, Norat T, Ferrari P, Jenab M, Bueno-de-Mesquita B, Skeie G, Dahm CC, Overvad K, Olsen A, Tjønneland A, Clavel-Chapelon F, Boutron-Ruault MC, Racine A, Kaaks R, Teucher B, Boeing H, Bergmann MM, Trichopoulou A, Trichopoulos D, Lagiou P, Palli D, Pala V, Panico S, Tumino R, Vineis P, Siersema P, van Duijnhoven F, Peeters PH, Hjartaker A, Engeset D, González CA, Sánchez MJ, Dorronsoro M, Navarro C, Ardanaz E, Quirós JR, Sonestedt E, Ericson U, Nilsson L, Palmqvist R, Khaw KT, Wareham N, Key TJ, Crowe FL, Fedirko V, Wark PA, Chuang SC, Riboli E (2012) Dietary fibre intake and risks of cancers of the colon and rectum in the European prospective investigation into cancer and nutrition (EPIC). PLoS One 7, e39361. doi:10.1371/journal.pone.0039361

National Cancer Forum (2006) A strategy for cancer control in Ireland. Department of Health and Children, Dublin. http://www.hse.ie/eng/services/Publications/HealthProtection/Public_Health_/National_Cancer_Control_Strategy.pdf. Accessed 2 March 2016

National Cancer Registry (2014) Cancer projections for Ireland 2015–2040. National Cancer Registry, Cork. http://www.ncri.ie/sites/ncri/files/pubs/Cancer%20projections%20for%20Ireland%202015%20-%202040.pdf. Accessed 2 March 2016

National Dairy Council (2013) Dairy intakes and compliance with food pyramid recommendations among Irish adults – findings from the national adult nutrition survey. National Dairy Council, Dublin

Ni Mhurchu C, Eyles H, Genc M, Scarborough P, Rayner M, Mizdrak A, Nnoaham K, Blakely T (2015) Effects of health-related food taxes and subsidies on mortality from diet-related disease in New Zealand: an econometric-epidemiologic modelling study. PLoS One 10, e0128477. doi:10.1371/journal.pone.0128477

Nikolić M, Glibetić M, Gurinović M, Milešević J, Khokhar S, Chillo S, Abaravicius JA, Bordoni A, Capozzi F (2014) Identifying critical nutrient intake in groups at risk of poverty in Europe: the CHANCE project approach. Nutrients 6:1374–1393. doi:10.3390/nu6041374

Ning Y, Wang L, Giovannucci EL (2010) A quantitative analysis of body mass index and colorectal cancer: findings from 56 observational studies. Obes Rev 11:19–30. doi:10.1111/j.1467-789X.2009.00613.x

Nishihara R, Wang M, Qian ZR, Baba Y, Yamauchi M, Mima K, Sukawa Y, Kim SA, Inamura K, Zhang X, Wu K, Giovannucci EL, Chan AT, Fuchs CS, Ogino S, Schernhammer ES (2014) Alcohol, one-carbon nutrient intake, and risk of colorectal cancer according to tumor methylation level of IGF2 differentially methylated region. Am J Clin Nutr 100:1479–1488. doi:10.3945/ajcn.114.095539

Nolan A, Layte R (2015) The 'healthy immigrant effect': breastfeeding behaviour in Ireland. Eur J Public Health 25:626–631. doi:10.1093/eurpub/cku177

O'Doherty MG, Cantwell MM, Murray LJ, Anderson LA, Abnet CC, FINBAR Study Group (2011) Dietary fat and meat intakes and risk of reflux esophagitis, Barrett's esophagus and esophageal adenocarcinoma. Int J Cancer 129:1493–1502. doi:10.1002/ijc.26108

O'Keeffe C, Kabir Z, O'Flaherty M, Walton J, Capewell S, Perry IJ (2013) Modelling the impact of specific food policy options on coronary heart disease and stroke deaths in Ireland. BMJ Open 3: pii: e002837. doi: 10.1136/bmjopen-2013-002837

Organisation for Economic Cooperation and Development (OECD) (2015) Health at a glance 2015 OECD indicators. OECD, Paris. doi: 10.1787/health_glance-2015-en. http://www.oecd-ilibrary.org/docserver/download/8115071e.pdf?expires=1474990301&id=id&accname=guest&checksum=0B987BB181E642B60485955CA6150DEF. Accessed 27 September 2016

Oyebode O, Gordon-Dseagu V, Walker A, Mindell JS (2014) Fruit and vegetable consumption and all-cause, cancer and CVD mortality: analysis of health survey for England data. J Epidemiol Community Health 68:856–862. doi:10.1136/jech-2013-203500

Pan A, Sun Q, Bernstein AM, Schulze MB, Manson JE, Stampfer MJ, Willett WC, Hu FB (2012) Red meat consumption and mortality: results from 2 prospective cohort studies. Arch Intern Med 172:555–563

Parkin DM, Boyd L, Walker LC (2011) The fraction of cancer attributable to lifestyle and environmental factors in the UK in 2010. Br J Cancer 105:S77–S81. doi:10.1038/bjc.2011.489

Pauwels EK, Kairemo K (2008) Fatty acid facts, part II: role in the prevention of carcinogenesis, or, more fish on the dish? Drug News Perspect 21:504–510. doi:10.1358/dnp.2008.21.9.1290819

Pelucchi C, Tramacere I, Boffetta P, Negri E, La Vecchia C (2011) Alcohol consumption and cancer risk. Nutr Cancer 63:983–990. doi:10.1080/01635581.2011.596642

Peterlik M, Grant WB, Cross HS (2009) Calcium, vitamin D and cancer. Anticancer Res 29:3687–3698

Qu X, Ben Q, Jiang Y (2013) Consumption of red and processed meat and risk for esophageal squamous cell carcinoma based on a meta-analysis. Ann Epidemiol 23:762–770. doi: 10.1016/j.annepidem.2013.09.003

Renehan AG, Soerjomataram I, Tyson M, Egger M, Zwahlen M, Coebergh JW, Buchan I (2010) Incident cancer burden attributable to excess body mass index in 30 European countries. Int J Cancer 126:692–702. doi:10.1002/ijc.24803

Riondino S, Roselli M, Palmirotta R, Della-Morte D, Ferroni P, Guadagni F (2014) Obesity and colorectal cancer: role of adipokines in tumor initiation and progression. World J Gastroenterol 20:5177–5190. doi:10.3748/wjg.v20.i18.5177

Romieu I, Scoccianti C, Chajes V, de Batlle J, Biessy C, Dossus L, Baglietto L, Clavel-Chapelon F, Overvad K, Olsen A, Tjønneland A, Kaaks R, Lukanova A, Boeing H, Trichopoulou A, Lagiou P, Trichopoulos D, Palli D, Sieri S, Tumino R, Vineis P, Panico S, Bueno-de-Mesquita HB, van Gils CH, Peeters PH, Lund E, Skeie G, Weiderpass E, Quirós García JR, Chirlaque MD, Ardanaz E, Sánchez MJ, Duell EJ, Amiano P, Borgquist S, Wirfält E, Hallmans G, Johansson I, Nilsson LM, Khaw KT, Wareham N, Key TJ, Travis RC, Murphy N, Wark PA, Ferrari P, Riboli E (2015) Alcohol intake and breast cancer in the European prospective investigation into cancer and nutrition. Int J Cancer 137:1921–1930. doi:10.1002/ijc.29469

Ryan AM, Duong M, Healy L, Ryan SA, Parekh N, Reynolds JV, Power DG (2011) Obesity, metabolic syndrome and esophageal adenocarcinoma: epidemiology, etiology and new targets. Cancer Epidemiol 35:309–319. doi:10.1016/j.canep.2011.03.001

Ryan AM, Cushen S, Schellekens H, Bhuachalla EN, Burns L, Kenny U, Power DG (2015) Poor awareness of risk factors for cancer in Irish adults: results of a large survey and review of the literature. Oncologist 20:372–378. doi:10.1634/theoncologist.2014-0453

Salehi M, Moradi-Lakeh M, Salehi MH, Nojomi M, Kolahdooz F (2013) Meat, fish, and esophageal cancer risk: a systematic review and dose–response meta-analysis. Nutr Rev 71:257–267. doi:10.1111/nure.12028

Schütze M, Boeing H, Pischon T, Rehm J, Kehoe T, Gmel G, Olsen A, Tjønneland AM, Dahm CC, Overvad K, Clavel-Chapelon F, Boutron-Ruault MC, Trichopoulou A, Benetou V, Zylis D, Kaaks R, Rohrmann S, Palli D, Berrino F, Tumino R, Vineis P, Rodríguez L, Agudo A, Sánchez MJ, Dorronsoro M, Chirlaque MD, Barricarte A, Peeters PH, van Gils CH, Khaw KT, Wareham N, Allen NE, Key TJ, Boffetta P, Slimani N, Jenab M, Romaguera D, Wark PA, Riboli E, Bergmann MM (2011) Alcohol attributable burden of incidence of cancer in eight European countries based on results from prospective cohort study. BMJ 342:d1584. doi:10.1136/bmj.d1584

Scoccianti C, Cecchini M, Anderson AS, Berrino F, Boutron-Ruault MC, Espina C, Key TJ, Leitzmann M, Norat T, Powers H, Wiseman M, Romieu I (2015a) European code against cancer 4th edition: alcohol

drinking and cancer. Cancer Epidemiol 39:S67–S74. doi:10.1016/j.canep.2015.01.007

Scoccianti C, Key TJ, Anderson AS, Armaroli P, Berrino F, Cecchini M, Boutron-Ruault MC, Leitzmann M, Norat T, Powers H, Schüz J, Wiseman M, Romieu I (2015b) European code against cancer 4th edition: breastfeeding and cancer. Cancer Epidemiol 39:S101–S106. doi:10.1016/j.canep.2014.12.007

Sharp L, Carsin AE, Cantwell MM, Anderson LA, Murray LJ, FINBAR Study Group (2013) Intakes of dietary folate and other B vitamins are associated with risks of esophageal adenocarcinoma, Barrett's esophagus, and reflux esophagitis. J Nutr 143:1966–1973. doi:10.3945/jn.113.174664

Shen XJ, Zhou JD, Dong JY, Ding WQ, Wu JC (2012) Dietary intake of n-3 fatty acids and colorectal cancer risk: a meta-analysis of data from 489 000 individuals. Br J Nutr 108: 1550–1556. doi:10.1017/S0007114512003546

Singh S, Sharma AN, Murad MH, Buttar NS, El-Serag HB, Katzka DA, Iyer PG (2013) Central adiposity is associated with increased risk of esophageal inflammation, metaplasia, and adenocarcinoma: a systematic review and meta-analysis. Clin Gastroenterol Hepatol 11: 1399–1412. doi:10.1016/j.cgh.2013.05.009

Singh S, Devanna S, Edakkanambeth Varayil J, Murad MH, Iyer PG (2014) Physical activity is associated with reduced risk of esophageal cancer, particularly esophageal adenocarcinoma: a systematic review and meta-analysis. BMC Gastroenterol 14: 101. doi:10.1186/1471-230X-14-101

Sjöström M, Oja P, Hagströmer M, Smith BM, Bauman A (2006) Health-enhancing physical activity across European Union countries: the Eurobarometer study. J Public Health 14:291–300. doi:10.1007/s10389-006-0031-y

Song M, Garrett WS, Chan AT (2015) Nutrients, foods, and colorectal cancer prevention. Gastroenterology 148:1244–1260. doi:10.1053/j.gastro.2014.12.035

Steck SE, Guinter M, Zheng J, Thomson CA (2015) Index-based dietary patterns and colorectal cancer risk: a systematic review. Adv Nutr 6: 763–773. doi:10.3945/an.115.009746

Tavani A, Malerba S, Pelucchi C, Dal Maso L, Zucchetto A, Serraino D, Levi F, Montella M, Franceschi S, Zambon A, La Vecchia C (2012) Dietary folates and cancer risk in a network of case–control studies. Ann Oncol 23:2737–2742

Tio M, Andrici J, Cox MR, Eslick GD (2014) Folate intake and the risk of upper gastrointestinal cancers: a systematic review and meta-analysis. J Gastroenterol Hepatol 29:250–258. doi:10.1111/jgh.12446

Touvier M, Chan DS, Lau R, Aune D, Vieira R, Greenwood DC, Kampman E, Riboli E, Hercberg S, Norat T (2011) Meta-analyses of vitamin D intake, 25-hydroxyvitamin D status, vitamin D receptor polymorphisms, and colorectal cancer risk. Cancer Epidemiol Biomarkers Prev 20: 1003–1016. doi:10.1158/1055-9965.EPI-10-1141

Turati F, Rossi M, Pelucchi C, Levi F, La Vecchia C (2015) Fruit and vegetables and cancer risk: a review of southern European studies. Br J Nutr 113(Suppl 2):S102–S110. doi:10.1017/S0007114515000148

Vainio H, Weiderpass E (2006) Fruit and vegetables in cancer prevention. Nutr Cancer 54:111–142

Vineis P, Wild CP (2014) Global cancer patterns: causes and prevention. Lancet 383:549–557. doi:10.1016/S0140-6736(13)62224-2

Volatier JL, Verger P (1999) Recent national French food and nutrient intake data. Br J Nutr 81(Suppl 2):S57–S59

Vollset SE, Clarke R, Lewington S, Ebbing M, Halsey J, Lonn E, Armitage J, Manson JE, Hankey GJ, Spence JD, Galan P, Bønaa KH, Jamison R, Gaziano JM, Guarino P, Baron JA, Logan RF, Giovannucci EL, den Heijer M, Ueland PM, Bennett D, Collins R, Peto R (2013) Effects of folic acid supplementation on overall and site-specific cancer incidence during the randomised trials: meta-analyses of data on 50,000 individuals. Lancet 381:1029–1036

Walton J (2011) National adult nutrition survey – summary report on food and nutrient intakes, physical measurements, physical activity patterns and food choice motives. Irish Universities Nutrition Alliance (IUNA), Dublin. http://www.iuna.net/wp-content/uploads/2010/12/National-Adult-Nutrition-Survey-Summary-Report-March-2011.pdf. Accessed 27 February 2016

Wang Y, Li F, Wang Z, Qiu T, Shen Y, Wang M (2015) Fruit and vegetable consumption and risk of lung cancer: a dose–response meta-analysis of prospective cohort studies. Lung Cancer 88:124–130. doi:10.1016/j.lungcan.2015.02.015

Wei MY, Garland CF, Gorham ED, Mohr SB, Giovannucci E (2008) Vitamin D and prevention of colorectal adenoma: a meta-analysis. Cancer Epidemiol Biomarkers Prev 17:2958–2969. doi:10.1158/1055-9965.EPI-08-0402

Wirth MD, Shivappa N, Steck SE, Hurley TG, Hébert JR (2015) The dietary inflammatory index is associated with colorectal cancer in the National Institutes of Health-American Association of Retired Persons diet and health study. Br J Nutr 113:1819–1827. doi:10.1017/S000711451500104X

World Cancer Research Fund UK (2012) Press release 6th February 2012: number of UK cancer cases up 30% by 2030. WCRF, London. http://www.irishhealth.com/article.html?id=20332. Accessed 14 July 2015

World Cancer Research Fund/American Institute for Cancer Research (2007) Food, nutrition, physical activity, and the prevention of cancer: a global perspective. AICR, Washington DC. http://www.aicr.org/assets/docs/pdf/reports/Second_Expert_Report.pdf. Accessed 27 September 2016

World Obesity Federation (2015) Adult overweight and obesity in the European Union (EU28) based on measured height and weight. World Obesity Federation, London. Available at: http://www.worldobesity.org/site_media/library/resource_images/EU_28_Adults_Feb_2015_.pdf. Accessed 22 July 2015

Xue XJ, Gao Q, Qiao JH (2014) Red and processed meat consumption and the risk of lung cancer: a dose–response meta-analysis of 33 published studies. Int J Clin Exp Med 7:1542–1553

Yang WS, Wong MY, Vogtmann E, Tang RQ, Xie L, Yang YS, Wu QJ, Zhang W, Xiang YB (2012) Meat consumption and risk of lung cancer: evidence from observational studies. Ann Oncol 23:3163–3170. doi:10.1093/annonc/mds207

Yin L, Ordóñez-Mena JM, Chen T, Schöttker B, Arndt V, Brenner H (2013) Circulating 25-hydroxyvitamin D serum concentration and total cancer incidence and mortality: a systematic review and meta-analysis. Prev Med 57:753–764. doi:10.1016/j.ypmed.2013.08.026

Yu XF, Zou J, Dong J (2014) Fish consumption and risk of gastrointestinal cancers: a meta-analysis of cohort studies. World J Gastroenterol 20:15398–15412. doi:10.3748/wjg.v20.i41.15398

Zanini S, Marzotto M, Giovinazzo F, Bassi C, Bellavite P (2015) Effects of dietary components on cancer of the digestive system. Crit Rev Food Sci Nutr 55:1870–1885. doi:10.1080/10408398.2012.732126

Zheng JS, Hu XJ, Zhao YM, Yang J, Li D (2013) Intake of fish and marine n-3 polyunsaturated fatty acids and risk of breast cancer: meta-analysis of data from 21 independent prospective cohort studies. BMJ 346:f3706. doi:10.1136/bmj.f3706

Zhou Y, Chen J, Li Q, Huang W, Lan H, Jiang H (2015) Association between breastfeeding and breast cancer risk: evidence from a meta-analysis. Breastfeed Med 10:175–182. doi:10.1089/bfm.2014.0141

Zhu HC, Yang X, Xu LP, Zhao LJ, Tao GZ, Zhang C, Qin Q, Cai J, Ma JX, Mao WD, Zhang XZ, Cheng HY, Sun XC (2014) Meat consumption is associated with esophageal cancer risk in a meat- and cancer-histological-type dependent manner. Dig Dis Sci 59:664–673. doi:10.1007/s10620-013-2928-y

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