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6.
Cancers attributable to dietary factors in the UK in 2010

III. Low consumption of fibre

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Dietary fibre has long been thought to be associated with a reduced risk of colorectal cancer (Burkitt, 1971). However, analytic epidemiological studies of dietary fibre and the risk of colorectal cancer have not yielded consistent associations. The first comprehensive meta-analysis of prospective studies showed no significant reduction in the risk of colorectal cancer with high consumption of fibre, but very low fibre intake (less than 10 g per day) did significantly increase bowel cancer risk (Park *et al*, 2005). The results of subsequent cohort studies seem to be split between those suggesting a protective effect of fibre (Bingham *et al*, 2003, 2005; Nomura *et al*, 2007; Wakai *et al*, 2007) and those showing no benefit (Otani *et al*, 2006; Shin *et al*, 2006). In some studies, null findings may be due to an insufficient range of fibre intake or other methodological problems; alternatively, other features of a high-fibre diet (a plant-based diet rich in fruits, vegetables and whole grains) could be responsible for the protective effect. The World Cancer Research Fund (WCRF) review (2007) concluded that, although there was a clear association, residual confounding could not be excluded as an explanation for the dose – response relationship between risk and fibre intake. In a subsequent study combining data from seven UK cohort studies (Dahm *et al*, 2010), fibre intake was ascertained by food diaries (rather than the less reliable food frequency questionnaires used in most studies), and issues of confounding (by anthropometric and socioeconomic factors, and dietary intake of folate, alcohol and energy) were addressed. A clear protective effect of fibre intake was observed, with a risk of colorectal cancer of 0.66 in the highest relative to the lowest quintile of intake.

Almost 20 years ago, the Committee on Medical Aspects of Food Nutrition Policy (COMA) Panel on Dietary Reference Values proposed that the diet of the UK adult population should contain on average 18 g per day non-starch polysaccharides, with an individual range of 12 – 24 g per day, from a variety of foods (Department of Health, 1991). This recommendation was repeated in the report of the COMA Working Group on Diet and Cancer (Department of Health, 1998), which had recommended 'an increase in average intake of non-starch polysaccharide in the adult population from 12 grams per day to 18 grams per day'. A measure of 18 g per day of NSP is equivalent to 23 g of fibre per day. The recommendation published by the Department of Health in 'Choosing a better diet: a food and action plan' (Department of Health, 2005) is to 'increase the average intake of dietary fibre to 18 grams per day (currently 13.8 grams per day)'. Presumably, this actually refers to dietary NSP, for which the average intake in 2000 – 2001 was 13.8 g (FSA, 2003).

In this section, we examine the potential effects of a deficit in consumption of fibre (below the recommended 23 g per day) on the incidence of colorectal cancer in the UK in 2005.

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METHODS

The relative risk of fibre intake, calculated by WCRF, was 0.9 per 10 g per day increment of dietary fibre (95% confidence interval 0.84 – 0.97). In the study of Dahm *et al* (2010), the value from the fully adjusted model was 0.84 (95% confidence interval 0.70 – 1.0). This is equivalent to a decline in risk of 2.9% per gram of fibre, and this value has been chosen for the estimation.

The latent period, or interval between 'exposure' to fibre and development of cancer, and the appropriate decrease in risk of cancers of the colon and rectum are not known. In the eight cohort studies contributing to the WCRF (2007) meta-analysis, the mean duration of follow-up was about 11 years. Therefore, an interval of 10 years is assumed, and the 2010 fraction of avoidable cancers is based on an estimate of the fibre intake in 2000.

Consumption of NSP, as grams per day, by age group and sex, is available for 2000 – 2001 from the National Diet and Nutrition Surveys (FSA, 2004; Tables 3.14 and 3.15). The relevant data are shown in Table 1.

The mean daily intake of NSP was significantly lower for women ($P < 0.01$) than for men. The youngest group had significantly lower mean intakes of NSP than those in any other age group. Median values were generally close to the mean within sex and age groups.

The three main sources of NSP, accounting for about three-quarters of the dietary intake, were cereals and cereal products (43%), vegetables excluding potatoes (20%), and potatoes and savoury snacks (16%). Within the cereals and cereal products group, whole-grain and high-fibre breakfast cereals provided 11% of the intake and white bread provided a further 9%. There were

Table 1 Average daily NSP intake (g) by sex and age of respondent, Great Britain 2000–2001

	Percentage of the population by age group				
NSP intake	**19–24**	**25–34**	**35–49**	**50–64**	**All**
Men (g per day)					
<6	6	0	2	1	2
6<8	10	8	6	5	6
8<10	17	15	11	8	12
10<12	9	15	11	11	12
12<14	26	12	14	13	15
14<16	21	16	16	11	15
16<18	5	11	10	12	10
18<20	2	10	9	11	9
20<22	1	3	5	12	6
22<24	3	4	5	5	5
⩾24	0	6	11	11	8
Mean					
NSP	12.3	14.6	15.7	16.4	15.2
Fibre	15.7	18.7	20.1	21.0	19.5
Women (g per day)					
<6	9	6	7	5	5
6<8	16	17	9	5	12
8<10	27	16	13	12	15
10<12	15	18	18	19	18
12<14	12	19	18	16	17
14<16	13	10	12	13	12
16<18	4	6	8	10	8
18<20	3	4	7	8	5
20<22	1	1	3	4	3
⩾22	0	3	5	8	5
Mean					
NSP	10.6	11.6	12.8	14	12.6
Fibre	13.6	14.8	16.4	17.9	16.1

Abbreviation: NSP = non-starch polysaccharide. Data from National Diet and Nutrition Survey, FSA (2004).

Table 2 NSP content of diet, Great Britain 2000–2001

Food items	**Grams NSP per gram food item**	**Grams NSP per day**	**% NSP intake**
Cereals and cereal products	0.023	5.91	43
Pasta, rice, miscellaneous cereals	0.006	0.42	3
Pasta	0.010	0.28	2
Other pasta, rice	0.003	0.14	1
Bread	0.028	2.82	20
White bread	0.019	1.27	9
Wholemeal bread	0.054	0.84	6
Other bread	0.037	0.70	5
Breakfast cereals	0.058	1.69	12
Other cereal products	0.018	0.99	7
Meat and meat products	0.005	0.84	6
Fish and fish products	0.005	0.14	1
Vegetables and vegetable dishes (excluding potatoes)	0.021	2.82	20
Baked beans	0.035	0.56	4
Other vegetables (not baked beans)	0.019	2.25	16
Potatoes and savoury snacks	0.020	2.25	16
Potato chips	0.020	0.70	5
Fried/roast potatoes and fried potato products	0.012	0.14	1
Other potatoes	0.017	0.99	7
Savoury snacks	0.038	0.28	2
Fruit and nuts	0.014	1.41	10
Sugar, preserves, confectionery	0.009	0.14	1
Miscellaneous[a]	—	0.28	2
Total	—	13.80	100

Abbreviation: NSP = non-starch polysaccharide. Data are from National Diet and Nutrition Survey, Vol. 2, FSA (2004). [a]Miscellaneous food items include powdered beverages (except tea and coffee), soups, sauces, condiments and artificial sweeteners.

no significant sex or age differences in the proportion of NSP provided by different food types (Table 2).

Assuming that 1 g of NSP corresponds to 1.28 g of fibre, the deficit (in grams) from the recommended 23 g per day can be estimated for each row of Table 1. Population-attributable fractions (PAFs) were calculated for each sex–age group in Table 2 according to the usual formula:

$$\mathrm{PAF} = \frac{(p_1 \times \mathrm{ERR}_1) + (p_2 \times \mathrm{ERR}_2) + (p_3 \times \mathrm{ERR}_3) \ldots + (p_n \times \mathrm{ERR}_n)}{1 + [(p_1 \times \mathrm{ERR}_1) + (p_2 \times \mathrm{ERR}_2) + (p_3 \times \mathrm{ERR}_3) \ldots + (p_n \times \mathrm{ERR}_n)]}$$

where p_x is the proportion of population in consumption category x and ERR_x is the excess relative risk in consumption category x.

ERR_x is calculated as follows:

$$\{\exp(R_g \times G_x) - 1\}$$

where R_g is the increase in risk for a deficit of 1 g per day of fibre (0.029) and G_x is the deficit in consumption (<23 g per day) in consumption category x.

RESULTS

Table 3 shows the estimated PAF and the number of cases of colorectal cancer 'caused' in 2010 by the deficit in consumption of fibre in 2000, by age group and sex. The excess number of cases is also expressed in terms of cancer as a whole. About 12.2% of colorectal cancer, or 1.5% of all cancers in 2010, is due to fibre consumption falling below the recommended daily intake of an average of 23 g (or 18 g NSP).

As discussed in Section 4 of this supplement (Parkin and Boyd, 2011), the benefit of consumption of fruits and vegetables on the risk of colorectal cancer may be, in part, due to their content of fibre. In calculating the cancer cases attributable to a deficient intake of dietary fruit and vegetables, the increased consumption that would have been necessary to achieve the '5-a-day' target (equivalent to 400 g of fruit and vegetable intake daily) was estimated. On the basis of the content of NSP in fruits and vegetables (in 2000–2001), we may estimate the additional consumption of fibre that is implied (Table 4). The increase is considerable – on average 4.1 g per day of fibre for men and 3.8 for women. With this addition to the distribution of fibre intake shown in Table 1, the mean intake (for all age groups 19–64) would be 23.6 g per day fibre for men, with only 30% consuming less than 23 g per day, and 16.4 g per day for women, with 58% consuming less than 23 g per day.

In Table 5, the numbers of cancer cases that would have been avoided by a diet containing 400 g per day of fruit and vegetable intake is presented, assuming that the benefit is due to the reduction in risk from the fibre content. Overall, the increase in dietary fibre intake from increasing the intake of fruits and vegetables to 400 g per day is estimated to reduce colorectal cancer by ~4.9% (4.4% in men and 5.5% in women). This is about two-fifths of the total benefit achievable from increasing the intake of fibre to 23 g per day, for those consuming less than this.

Table 3 Projected number of colorectal and all cancer cases in UK in 2010 and proportion due to deficient intake of NSP

Age (years)		Colorectal cancer			All cancer[a]		
At exposure	At outcome	Observed cases	Excess attributable cases	PAF (%)	Observed cases	Excess attributable cases	PAF (%)
Men							
19–24	29–34	92	14	15.1	1333	14	1.0
25–34	35–44	397	42	10.6	4124	42	1.0
35–49	45–59	2921	276	9.5	22 388	276	1.2
50–64	⩾60	18 643	1932	10.4	128 192	1932	1.5
	All ages	22 127	2264	10.2	158 667	2264	1.4
Women							
19–24	29–34	97	19	19.5	2248	19	0.8
25–34	35–44	402	82	20.5	8619	82	1.0
35–49	45–59	2292	364	15.9	31 631	364	1.1
50–64	⩾60	14 926	2127	14.2	110 403	2127	1.9
	All ages	17 787	2592	14.6	155 584	2592	1.7
Persons							
19–24	29–34	189	33	17.3	5096	33	0.6
25–34	35–44	799	124	15.6	18 704	124	0.7
35–49	45–59	5213	640	12.3	73 321	640	0.9
50–64	⩾60	33 569	4059	12.1	183 745	4059	2.2
	All ages	39 914	4856	12.2	314 251	4856	1.5

Abbreviations: NSP = non-starch polysaccharide; PAF = population-attributable fraction. [a]Excluding non-melanoma skin cancer.

Table 4 Estimated additional consumption of fibre from increasing fruit and vegetable intake to 400 g per day from the levels observed in 2000–2001

	Increase in fibre consumption (g per day) by age group				
	19–24	25–34	35–49	50–64	All ages
Males	7.9	5.5	3.9	2.7	4.1
Females	6.8	3.8	3.9	2.4	3.8

Table 5 Projected number and proportion of colorectal cancer cases avoidable in 2010 from the fibre intake associated with five servings (400 g) of fruit and vegetables daily

Age (years)		Colorectal cancer		
			Reduction in cases	
At exposure	At outcome	Observed cases	Number	%
Men				
19–24	29–34	92	11	11.7
25–34	35–44	397	31	7.7
35–49	45–59	2921	163	5.6
50–64	⩾60	18 643	771	4.1
	All ages	22 127	975	4.4
Women				
19–24	29–34	97	13	13.4
25–34	35–44	402	34	8.4
35–49	45–59	2292	184	8.0
50–64	⩾60	14 926	748	5.0
	All ages	17 787	978	5.5
Persons				
19–24	29–34	189	24	12.6
25–34	35–44	799	64	8.1
35–49	45–59	5213	346	6.6
50–64	⩾60	33 569	1519	4.5
	All ages	39 914	1954	4.9

DISCUSSION

In the analysis presented here, we examine both the possible number of colorectal cancers due to a deficit in consumption of fibre less than the recommended 23 g per day and the effect of a deficit in consumption of fruit and vegetables (below the recommended '5 a day'), assuming that the benefit of fruit and vegetables is solely the result of their fibre content. The latter depends not only on the supposition that fibre is indeed protective against colorectal cancer, but also on the assumption that all forms of fibre are equally protective. This is not universally accepted; in the study by Schatzkin *et al* (2007), for example, only fibre from grains was associated with a lower risk of colorectal cancer.

The UK-recommended average intake of NSP in the adult population is 18 g per day (equivalent to 23 g per day of fibre). The WCRF (2007) set a much more ambitious public health goal, as 'a population average of at least 25 grams non-starch polysaccharide daily' (equivalent to 32 g of dietary fibre). In their estimates of 'preventability' of colorectal cancer in the UK in 2002 (WCRF, 2009), an estimated 12% of colorectal cancer was stated as preventable by increasing fibre intake to 30 g per day, based on the effects estimated by Park *et al* (2005): a relative risk of 1.14 for an intake of ⩽10 g per day relative to ⩾30 g per day.

Although there is no direct evidence from intervention studies of the effect of dietary and supplemental fibre on colorectal cancer, several trials have been carried out on the effects of fibre supplements on recurrence of colonic adenomas. The results as reported were negative (Maclennan *et al*, 1995; Alberts *et al*, 2000; Schatzkin *et al*, 2000), although the period of supplementation and follow-up was very short (2–4 years). A pooled reanalysis of the two US trials showed a statistically significant interaction by sex, and a beneficial effect of the intervention in men (odds ratio = 0.81, 95% CI = 0.67–0.98; Jacobs *et al*, 2006).

See acknowledgements on page Si.

Conflict of interest

The authors declare no conflict of interest.

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