



Reduced mortality among whole grain bread eaters in men and women in the Norwegian County Study

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Objective: To study whether mortality is reduced among whole grain eaters in Norway.

Design: Non-interventional, prospective, baseline 1977–1983, followed for mortality through to 1994.

Setting: Three Norwegian counties.

Subjects: A total of 16 933 men and 16 915 women; systematic screening of all residents aged 35–56 y at baseline, not disabled and free of cardiovascular disease (79% response rate).

Predictor variable: We combined self-report of type and number of bread slices (white, light whole grain, dense whole grain) to form a whole grain bread score, with range 0.05 (1 slice per day, made with 5% whole grain flour) to 5.4 (9 slices per day, made with 60% whole grain flour).

Results: Norwegian whole grain bread eaters were less likely to be smokers, were more physically active, had lower serum cholesterol and systolic blood pressure, and ate less total and saturated fat as a proportion of energy intake than white bread eaters. After adjustment for age, energy intake, sex, serum cholesterol, systolic blood pressure, smoking, body mass index, physical activity at leisure and work, and use of cod liver oil or other vitamin supplements, hazard rate ratios (HRR) for total mortality were inverse and graded across whole grain bread score categories (category 5 vs category 1 HRR: 0.75, 95% confidence interval 0.63–0.89 in men and 0.66, 0.44–0.98 in women).

Conclusion: Protection by whole grain intake against chronic disease is suggested in Norway, where four times as much whole grain is consumed as in the United States.

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Descriptors: whole grain; bread; mortality; epidemiology; nutrition

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Introduction

Prospective studies have found that habitual intake of whole grain foods is associated with reduced total, coronary heart disease, total cancer mortality (Jacobs *et al*, 1998a, 1999, 2000) and incident diabetes (Meyer *et al*, 2000) in Iowa women, and with coronary heart disease mortality in nurses across the United States (Liu *et al*, 1999). Reduced risk of coronary heart disease was seen with higher rye bread consumption in Finland (Pietinen *et al*, 1996), increased cold breakfast cereal consumption in male health professionals (Rimm *et al*, 1996) and with

preference for whole wheat bread in Seventh Day Adventist men and women (Fraser *et al*, 1992). Intake of dietary fiber, especially from grain sources, was observed to be related to reduced coronary heart disease in nurses (Wolk *et al*, 1999) and to reduced diabetes in Iowa women (Meyer *et al*, 2000), nurses and male health professionals (Salmeron *et al*, 1997a,b). Case–control studies consistently find inverse associations of whole grain intake with various forms of cancer (Jacobs *et al*, 1995, 1998b; Chatenoud *et al*, 1998). Whole grain foods contain a wide variety of biologically active constituents, which may contribute synergistically to reduced rates of various chronic diseases (Slavin *et al*, 1997). Many of the biologically active constituents are lost when the bran and the germ are removed in the process of refining grain to make flour.

Indeed, based in part on this evidence, the recently released United States Department of Agriculture Dietary Guidelines (www.ars.usda.gov/dgacl) suggest that people ‘eat a variety of grains daily, especially whole grains’, whereas the previous guideline grouped the recommendation for grain with fruits and vegetables, and did not specifically refer to whole grain (Proposed dietary

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guidelines for Americans). Norwegian guidelines also specifically recommend increased use of whole grain products (National Council on Nutrition and Physical Activity, 1999). In the United States, about 23% of energy intake comes from grain, but only about 5% of that comes from whole grain (Jacobs *et al*, 1999). Norway is a country in which, according to food disappearance data, the intake of whole grain foods is four times that in the United States (Development of the Norwegian Diet, 1998), although lower than in Finland (Food and Agriculture Organization of the United States (FAO), 1999). A prospective study of middle-aged men and women living in three Norwegian counties, carried out during the years 1977–1983, included a dietary questionnaire. Using this questionnaire, we formed a whole grain bread score that encompassed the usual amount and density of bread eaten: the denser the bread, the higher the content of whole grain particles or flour. We used this information to study whether whole grain bread intake is related to lower mortality risk in this setting.

Methods

Between 1977 and 1983, the National Health Screening Service of Norway invited all 52 023 men and women living in the counties of Finnmark, Sogn og Fjordane, and Oppland to a second screening for cardiovascular risk factors and disease (Bjartveit *et al*, 1979, 1983; Meyer *et al*, 1993). Participants (defined by having a valid serum cholesterol measurement) were 47 114 (90.6% of all invited) men and women, aged 35–56 y, born between 1925 and 1942 in Finnmark, between 1926 and 1940 in Sogn og Fjordane and between 1927 and 1941 in Oppland. Participants received a dietary questionnaire at the screening and returned by mail. In all 41 174 (87.4% of attenders, 79.2% of all invited) filled out the questionnaire in sufficient detail to compute an estimate of energy intake and the whole grain bread score (described below). Participants were followed until 31 December, 1994 by linkage to emigration and mortality files maintained by Statistics Norway (Meyer *et al*, 1997). The whole grain bread score was available in 20 658 men and 20 516 women; of these 3725 men and 3601 women were on disability pension, had symptoms or history of cardiovascular disease, or were missing covariate information at baseline. History and symptoms of cardiovascular disease were based on self-report of myocardial infarction, angina pectoris, other heart disease, arteriosclerosis of legs, cerebral stroke, diabetes, treatment for hypertension, use of nitroglycerine, and symptoms of angina pectoris or atherosclerosis obliterans. Being on a disability pension was based on a single question. These groups are omitted because of the likelihood that they have modified their diet in response to disease. The final sample consisted of 16 933 men and 16 915 women.

Diet was queried using a semi-quantitative, 66-item food frequency questionnaire (Gaard *et al*, 1996). The questionnaire included information about intake of specific foods, modes of preparation, and pattern of eating during the day. It focused strongly on intake of bread, meat, fish, milk,

coffee, oranges, potatoes, cakes and fat, with no other information on fruit and vegetables. As described elsewhere (Gaard *et al*, 1995, 1996), nutrient and total intakes were calculated by multiplying the frequencies of consumption of food items by the nutrient or energy content of a standard portion as specified in the Norwegian food composition table (Blaker & Rimestad, 1991). Although the questionnaire was relatively brief, and energy intake is probably underestimated, it is likely that the ranking of individuals by energy intake is reasonable.

Four questions asked about bread intake: (1) how many slices of bread do you usually eat per day? (Possible answers: <2 slices per day; 2–4; 5–6; 7–8; 9–12; 13 or more); (2) what kind of bread do you eat most often? (Possible answers: store bought; home-baked); (3) If you buy, what type most often? (Possible answers: white bread, fine or light bread, whole grain or dark bread); (4) If you bake at home, what proportion of the flour is whole grain (dark)? (Possible answers: don't use whole grain flour; <1/4 whole grain flour; 1/4–1/2 whole grain flour; more than 1/2 whole grain flour). The questionnaire was evaluated against data from one 24 h recall performed among 748 men and 861 women (Solvoll, 1983). For the bread questions, the largest difference arose for question 3, type of bread most often bought in stores. Of both men and women, 73% reported on the questionnaire that it was most often dark bread, compared to 34% of men and 37% of women who reported dark bread in the recall. There was a smaller tendency for the food frequency questionnaire (question 1) to overestimate the intake of bread (questionnaire: mean intake 7.0 and 4.0 slices per day for men and women, respectively, compared to 6.5 and 3.3 slices per day from the 24 h recall). Use of home-made bread was slightly more frequently reported in the questionnaire (question 2) than in the recall (54% vs 49% among men, 59% vs 50% among women). A somewhat higher proportion of whole grain flour was reported on the questionnaire (question 4) than on the recall.

A whole grain bread score was formed as the product of the number of slices of bread eaten per day times the proportion of whole grain flour. Number of slices of bread was the response to question 1, quantitated as follows: <2 slices per day = 1; 2–4 = 3; 5–6 = 5.5; 7–8 = 7.5; 9–12 = 9; 13 or more = 9. The proportion whole grain flour used was quantitated as follows: don't use whole grain flour = 5%; <1/4 whole grain flour = 15%; 1/4–1/2 whole grain flour = 30%; more than 1/2 whole grain flour = 60%. For those who said they ate mostly home-made bread, the proportion of whole grain flour used was taken directly from question 4. Some of those who said they ate mostly store bought bread also answered question 4. Given the tendency in the questionnaire evaluation study (Solvoll, 1983) for those who ate mostly store-bought bread to overestimate the coarseness of the flour used, the answer to question 4 was downgraded one category (eg, 'more than 1/2 whole grain flour' to '1/4–1/2 whole grain flour') for those who bought their bread. However, we did not downgrade question 4 if the participant said he or she ate mostly

store bought whole grain bread, but it was composed of < 1/4 whole grain flour. If question 4 was not answered, the flour coarseness index was set to '< 1/4 whole grain flour' for participants who ate mostly store bought whole grain bread, or to 'don't use whole grain flour' for participants who ate mostly lighter or white bread.

Cause of death was assigned based on ICD 8 and 9 codes by nosologists at Statistics Norway. In addition to total mortality, we studied the underlying causes of coronary heart disease (ICD 8: 410–414, 428, 429.0, 782.4, 795; ICD 9: 410–414, 428, 429.0–429.2, 798.1–798.2), total cardiovascular disease (ICD 8 and 9: 390–459), total

Table 1 Frequencies and total death rates (adjusted for age and energy intake) among men and women free of cardiovascular disease and not on disability pension, according to answers to the bread questions and for the final whole grain bread score; the Cardiovascular Disease Study in Norwegian Counties, 1977–1983

<i>A. Calculated index for percentage of whole grain flour used in bread (computed by above algorithm)</i>					
<i>Percentage whole grain flour</i>					
	5%	15%	30%	60%	
Men	1687	8120	6151	1484	
Total dead (%)	10.8	8.0	7.4	7.2	
Women	866	6987	7502	1851	
Total dead (%)	4.6	3.9	3.8	3.5	
<i>B. Number of slices of bread usually eaten per day (question 1)</i>					
<i>Slices of bread</i>					
	1	3	5.5	7.5	9
Men	129	2540	6099	5672	3002
Total dead (%)	11.2	9.1	8.4	7.5	6.9
Women	845	10055	5214	968	124
Total dead (%)	6.1	4.2	3.0	3.1	2.6
<i>C. Whole grain bread score: slices eaten per day (question 1) times the percentage whole grain flour used in bread</i>					
<i>Whole grain bread score</i>					
	(0.05–0.60)	(0.83–0.83)	(0.90–1.13)	(1.35–1.80)	(2.25–5.40)
Men	3001	2812	3462	3743	4424
Median score	0.38	0.83	1.13	1.65	2.7
Total dead (%)	10.0	8.3	7.2	7.9	7.0
Women	5797	2075	4703	3512	1119
Median score	0.45	0.83	0.90	1.65	3.30
Total dead (%)	4.6	2.8	4.1	3.5	2.7

(A) *P*-values for any difference among four categories: men, < 0.001; women, 0.57.

(B) *P*-values for any difference among five categories: men, 0.36; women, 0.03.

(C) *P*-values for any difference in mortality among five categories: men, < 0.001; women, 0.007.

Table 2 Distribution of whole grain bread score and associations with covariates among men free of cardiovascular disease and not on disability pension; the Cardiovascular Disease Study in Norwegian Counties, 1977–1983

<i>Whole grain bread score category</i>						
	(0.05–0.60)	(0.83–0.83)	(0.90–1.13)	(1.35–1.80)	(2.25–5.40)	<i>P linear</i>
Age (y)	46.5	46.5	46.3	45.6	45.6	< 0.001
Energy intake (kJ/day)	6505	7345	8083	8442	8894	< 0.001
Body mass index (kg/m ²)	25.3	25.3	25.4	25.4	25.2	0.034
Current smoker (%)	55	49	47	43	41	< 0.001
Physical inactivity during leisure time (%)	19.6	14.5	15.1	14.0	13.6	< 0.001
Physical inactivity at work (%)	25.3	26.9	25.5	27.2	25.0	0.08
Serum total cholesterol (mmol/l)	6.27	6.25	6.23	6.28	6.23	0.18
Systolic blood pressure (mmHg; second measurement)	137.1	136.3	136.3	135.8	135.6	0.002
Total fat intake (g/day)	86.6	81.5	79.8	80.0	80.5	< 0.001
Saturated fat intake (g/day)	38.2	35.4	34.5	34.6	34.9	< 0.001
Cod liver oil (%) (customary use)	10.0	11.8	11.2	13.1	14.0	< 0.001
Multivitamin supplementation (%) (customary use)	18.6	19.1	20.0	20.4	20.6	0.28

All values are means or percentages. Adjusted for age and energy intake, except that age and energy intake are adjusted only for each other. *P* is for any difference across whole grain bread score categories among the means or percentages given.

cancer (ICD 8 and 9: 140–208; plus ICD 9: 238.6), and all other causes.

We categorized participants in five categories of their whole grain bread score. Because of uneven distributions, the number of participants was unequal between categories, especially in categories 2 and 5 for women (Table 1). Using multiple linear regression analysis, we examined sex-specific differences between these categories in mean age adjusted for energy intake, mean energy intake adjusted for age, and age- and energy intake-adjusted mean levels of several other covariates (listed in Tables 2 and 3 and described in detail elsewhere; Bjartveit *et al*, 1979, 1983; Meyer *et al*, 1993, 1997; Gaard *et al*, 1995, 1996).

Using proportional hazards regression analysis, we studied the relationships between total mortality and each cause of death (as dependent variables) and category of the whole grain bread score. In the minimally adjusted model, only age, energy intake and sex were adjusted for. We also ran more fully adjusted models, including as covariates all of the variables in Tables 2 and 3, except total fat. We repeated these analyses for men and women separately.

We repeated all analyses using an alternative grouping of the whole grain bread score. In this case we first formed the residual of whole grain bread score given energy intake (Willett & Stampfer, 1986), then formed sex-specific quintiles. This analysis had the advantage that the whole grain bread intake in each quintile was similar between men and women after accounting for energy intake. Findings were very similar to those using the grouping presented in this paper (data not shown).

All analyses were done using the Statistical Package for the Social Sciences (SPSS, 1999).

Results

Men reported eating 6.3 ± 2.0 slices of bread per day in a diet containing energy intake of 7847 ± 2242 kJ (1915 kcal)

per day, vs 3.9 ± 1.6 slices per day among women, in a diet containing energy intake of 5211 ± 1531 kJ (1271 kcal) per day. Men used $22.8 \pm 13.9\%$ whole grain flour in their bread, compared to $25.6 \pm 14.2\%$ among women. Number of slices eaten and coarseness of flour used were uncorrelated ($r=0.01$ in men and -0.01 in women). The whole grain bread score (slices per day times proportion of whole grain flour) had mean 1.43 ± 1.00 among men and 1.00 ± 0.71 among women. However, after adjustment for age and energy intake, the mean whole grain bread score was virtually identical between sexes: 1.21 among men and 1.22 among women.

Those who had the highest whole grain bread score were less than 1 y of age younger than those who had the lowest whole grain bread score (Tables 2 and 3). Energy intake increased in a stepwise fashion across whole grain bread score categories, with the exception of category 2 among women. After adjustment for age and energy intake, there was little difference among whole grain bread score categories for body mass index in both men and women, and for being physically inactive at work, or taking multivitamin supplements among men. Otherwise, whole grain bread eaters had a more favorable profile of health behaviors and diet. Those who ate more whole grain bread had slightly reduced serum total cholesterol and systolic blood pressure, particularly among women. Both men and women were less likely to be cigarette smokers, were more active in leisure time, and were more likely to take cod liver oil on a customary basis, and women were less likely to be physically inactive at work and were more likely to take multivitamin supplements. Both men and women who had a high whole grain bread score consumed less total and saturated fat per unit of energy intake. In men and women combined (Table 4), person-years of followup were lower in the second and fifth categories of the whole grain bread score. A total of 1342 men and 649 women died of any cause during follow-up. Compared to the lowest category of the whole grain bread score, after adjustment for age and energy intake, those in category 5 had a hazard rate ratio

Table 3 Distribution of whole grain bread score and associations with covariates among women free of cardiovascular disease and not on disability pension, the Cardiovascular Disease Study in Norwegian Counties, 1977–1983

	Whole grain intake category					P linear
	(0.05–0.60)	(0.83–0.83)	(0.90–1.13)	(1.35–1.80)	(2.25–5.40)	
Age (y)	46.5	46.3	45.8	46.0	45.5	<0.001
Energy intake (kJ/day)	4498	6787	4675	5709	7297	<0.001
Body mass index (kg/m ²)	24.6	24.6	24.7	24.6	24.5	0.27
Current smoker (%)	42	33	33	29	25	<0.001
Physical inactivity during leisure time (%)	19.2	16.1	14.4	12.2	12.8	<0.001
Physical inactivity at work (%)	16.4	16.7	11.9	11.9	11.5	<0.001
Serum total cholesterol (mmol/l)	6.24	6.10	6.27	6.20	6.14	<0.001
Systolic blood pressure (mmHg; second measurement)	132.3	131.9	132.1	130.8	130.1	<0.001
Total fat intake (g/day)	53.9	47.1	53.5	50.4	44.5	<0.001
Saturated fat intake (g/day)	23.3	20.3	23.0	21.7	19.4	<0.001
Cod liver oil (%) (customary use)	11.1	8.7	15.3	17.1	17.6	<0.001
Multivitamin supplementation (%) (customary use)	42.0	41.4	45.2	43.4	43.7	0.009

All values are means or percentages. Adjusted for age and energy intake, except that age and energy intake are adjusted only for each other. *P* is for any difference across whole grain bread score categories among the means or percentages given.

(HRR) of 0.66 (95% confidence interval 0.57–0.77, Table 4). These HRRs were attenuated by further adjustment for other diet, lifestyle and risk factors: those in category 5 had a hazard rate ratio (HRR) of 0.75 (95% confidence interval 0.65–0.88). In separate analyses of men and women, HRR was 0.75 (95% confidence interval 0.63–0.89, P for linear trend = 0.01) among men and HRR 0.66 (95% confidence interval 0.44–0.98, P for linear trend = 0.16) among women. Analyses of mortality rates according to the components of the whole grain bread score showed that both the number of slices of bread eaten daily and the proportion of whole grain flour used contributed to these inverse trends (Table 1).

During follow-up, 587 men and 146 women died of cardiovascular disease; death was attributed to coronary heart disease in 456 of these men and 79 of these women. In analyses of men and women combined (Table 4), both coronary heart disease and cardiovascular disease death were reduced by about 23% in the highest category of the whole grain bread score, compared to its lowest category. In separate analyses of men and women, the pattern was similar, although more variable (data not shown).

Any cancer was the cause of death in 450 men and 393 women. After adjustment, there was a 21% reduction in

cancer death rate in those with the highest whole grain bread score, compared to those with the lowest (P for linear trend = 0.07, Table 4). The pattern was similar but more variable in separate analyses of men and women (data not shown).

Other non-cardiovascular, non-cancer causes of death occurred in 305 men and 110 women. A nonlinear trend in mortality was seen, in which those in categories 2–5 had HRR of 0.60–0.78, compared to the lowest category of the whole grain bread score (Table 4). Similar nonlinear trends were seen in separate analyses of men and women (data not shown).

Discussion

This study finds reduced death rates in healthy, middle-aged, Norwegian, whole grain eaters in several disease categories, suggestive of reduced chronic disease, in agreement with findings concerning whole grain in women (Jacobs *et al*, 1998a, 1999, 2000; Meyer *et al*, 2000; Liu *et al*, 1999; Fraser *et al*, 1992) and men (Fraser *et al*, 1992) in the United States and in male smokers in Finland (Pietinen *et al*, 1996). The findings are also consonant

Table 4 Proportional hazards regression analysis of mortality. Hazard rate ratios (HRR) and their confidence intervals for the four higher categories of whole grain bread score, in relation to the lowest category; 33848 men and women free of history and symptoms of cardiovascular disease and not on disability pension, the Cardiovascular Disease Study in Norwegian Counties, 1977–1983

	Whole grain intake category					<i>P</i> linear trend
	(0.05–0.60)	(0.83–0.83)	(0.90–1.13)	(1.35–1.80)	(2.25–5.40)	
Person-years	121849	67336	116241	103820	79254	
Total deaths	565	311	430	417	335	
HRR ^a	1	0.82	0.74	0.76	0.66	< 0.0001
95%CI		0.71–0.95	0.65–0.85	0.66–0.87	0.57–0.77	
Adjusted HRR ^b	1	0.87	0.80	0.85	0.75	0.006
95%CI		0.75–1.01	0.71–0.92	0.74–0.98	0.65–0.88	
CHD deaths	136	94	122	105	96	
HRR	1	0.92	0.85	0.75	0.63	0.001
95%CI		0.70–1.20	0.66–1.09	0.58–0.99	0.47–0.85	
Adjusted HRR	1	0.99	0.94	0.88	0.76	0.04
95%CI		0.75–1.31	0.73–1.22	0.67–1.16	0.56–1.02	
CVD deaths	196	124	159	144	135	
HRR	1	0.86	0.76	0.72	0.64	0.0002
95%CI		0.68–1.09	0.61–0.95	0.58–0.91	0.50–0.82	
Adjusted HRR	1	0.93	0.84	0.84	0.77	0.016
95%CI		0.73–1.18	0.68–1.05	0.66–1.05	0.60–0.98	
Cancer deaths	238	130	197	181	124	
HRR	1	0.91	0.84	0.82	0.72	0.009
95%CI		0.73–1.14	0.69–1.02	0.67–1.01	0.56–0.92	
Adjusted HRR	1	0.96	0.89	0.90	0.79	0.07
95%CI		0.76–1.20	0.73–1.08	0.73–1.11	0.62–1.02	
Noncardiovascular and noncancer deaths	131	57	74	92	76	
HRR	1	0.58	0.55	0.69	0.57	0.21
95%CI		0.42–0.81	0.41–0.74	0.52–0.91	0.41–0.78	
Adjusted HRR	1	0.62	0.60	0.78	0.65	0.73
95%CI		0.45–0.87	0.45–0.81	0.58–1.04	0.47–0.90	

^aMinimal model adjusted for age, energy intake, and sex.

^bAdditional covariates in the full model are current smoking, past smoking, physical activity during leisure, physical activity during work, customary use of cod liver oil, customary use of multivitamins, saturated fat intake, systolic blood pressure, serum total cholesterol, body mass index.

with findings for cereal fiber in men (Rimm *et al*, 1996; Wolk *et al*, 1999; Salmeron *et al*, 1997b) and women (Salmeron *et al*, 1997a) in the United States. As in the United States (Jacobs *et al*, 1998a), whole grain bread intake in Norway is related to other positive health behaviors and to reduced blood pressure. The association of whole grain intake is partially attenuated after regression adjustment for these factors, but remains statistically significantly inverse. The association of whole grain bread intake with mortality was most consistently graded for cardiovascular diseases, followed by cancers. However, as in the Iowa Women's Health Study (Jacobs *et al*, 1999), the association with total cancer death was weaker than that with cardiovascular disease and did not reach statistical significance after adjustment for health behaviors. Furthermore, the reduction in mortality rate was greatest for noncardiovascular, noncancer causes, about 35%, even in those with a relatively low whole grain bread score. Findings were similar in men and in women, although deaths were few in women and only total mortality was clearly statistically significantly reduced among whole grain eaters.

An association of whole grain intake with reduced risk for several chronic diseases is biologically reasonable because of the high nutritional quality of whole grain; the great bulk of nutrients and biologically active constituents in grain are found in the bran and the germ (Slavin *et al*, 1997). The endosperm, from which refined grain foods such as white wheat flour and white rice is made, is primarily starch. The finding of this study is of particular interest because it extends the findings from the United States for differential risk according to amount of whole grain intake to the higher intake levels customarily consumed by Norwegians.

All dietary surveys, including this one, suffer from high within-person error in self-reported diet. This error tends to flatten the association of dietary factors such as whole grain intake with disease endpoints. Furthermore, the bread questions were validated in relation to a study using 24 h recalls (Solvoll, 1983), and the algorithm for the whole grain bread score adjusted before looking at mortality findings according to results of the validation study. The study questionnaire omits many foods, particularly of plant origin, given the interest primarily in dietary fat at the time this survey was administered. The energy intake is probably underestimated (Gaard *et al*, 1996) by perhaps 20–30% (Løken & Solvoll, 1997). It is a major limitation that the survey contains very little information about intake of other plant products besides bread, potatoes and oranges. Based on 24 h recall data, intake of fruits and vegetables are quite different in Norway than in the United States. In the country of Oppland in 1982, average intake of fruit and vegetables, other than potatoes, was about 230 g/day, while 170 g/day of potatoes were eaten (Solvoll *et al*, 1985). In the current study, only oranges were queried, and they constituted about 30% of total fruit intake. In comparison, adults in the United States in 1994–1996, consumed about 375 g/day of fruit and vegetables including potatoes, which

are eaten in smaller quantities in the United States than in Norway (Enns *et al*, 1997). Even though fruit and vegetable intake in Norway was less varied than in the United States, it may be that those who ate the most whole grain bread also ate the most fruit and vegetables. It is reasonable to suppose that any protective effect of whole grain intake would act synergistically with intake of other nutrient-rich plant products. Another limitation is that this report included only total cancer and noncardiovascular, non-cancer deaths. Future plans include an in-depth look at which specific cancers and other diseases were reduced in whole grain eaters.

This study extends findings in the US of decreased risk in those who eat more whole grain foods to a population in which whole grain intake is common. Given the nutrient-rich content and biological activity of whole grain foods, it is reasonable to recommend to the general public that more whole grain products be consumed. However, the study did not include information about fruit and vegetable intake, and we bear in mind that findings for whole grain in this study may in part reflect the influence of fruit and vegetable intake.

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