



Original Contribution

School Milk and Risk of Colorectal Cancer: A National Case-Control Study

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To determine whether school milk consumption in childhood decreased the risk of adult colorectal cancer, the authors conducted a national population-based, case-control study of 562 cases and 571 controls. The authors identified new cases of colorectal cancer in 2007 among people aged 30–69 years from the New Zealand Cancer Registry. Controls were randomly selected from the electoral rolls and frequency matched to cases in 5-year age groups. Participation in school milk programs was associated with a reduced odds ratio for colorectal cancer (odds ratio (OR) = 0.70, 95% confidence interval (CI): 0.51, 0.96). Odds ratios decreased with increasing numbers of bottles of milk drunk compared with no school milk (for 1–799 bottles, OR = 1.04, 95% CI: 0.66, 1.67; for 800–1,199 bottles, OR = 0.81, 95% CI: 0.51, 1.29; for 1,200–1,599 bottles, OR = 0.62, 95% CI: 0.41, 0.93; for 1,600–1,799 bottles, OR = 0.57, 95% CI: 0.37, 0.90; and for 1,800 or more bottles, OR = 0.62, 95% CI: 0.41, 0.96). Participation in school milk programs in New Zealand was associated with a 2.1% reduction (95% CI: 0.7, 3.5) in the odds ratio for colorectal cancer for every 100 half-pint bottles drunk (1 half-pint bottle = 284 mL).

calcium; case-control studies; child; colorectal neoplasms; milk

Abbreviations: CI, confidence interval; OR, odds ratio.

New Zealand has one of the highest incidence rates of colorectal cancer in the world (1) but, for successive generations born from about 1937 onward, the incidence of colorectal cancer has decreased (2). Data from the New Zealand Cancer Registry show that this decrease has persisted, with the age-specific rates in those born from about 1938 to about 1953 up to 50% lower than those of earlier generations at all ages (Figure 1). This suggests that there may be important environmental factors acting during pregnancy, childhood, or adolescence that affect the risk of developing colorectal cancer.

Most research has concentrated on factors in adulthood that may alter the risk of colorectal cancer with a wide range of proposed exposures and mechanisms potentially contributing, mainly through effects on the development of adenomas or their progression to invasive cancer (3). Some adenomas are thought to develop in young adulthood, and their prevalence increases with age (4). Although calcium supplementation in adults has been shown to reduce the risk of recurrent adenoma (5, 6), the effect of childhood dietary

calcium on their initial development is unknown. Protection from toxic bile acids, enhancement of apoptosis, and promotion of cellular differentiation have all been suggested as anticarcinogenic actions of calcium (7–9). However, a cohort study in the United Kingdom assessing family diet during childhood and the risk of malignancies in adulthood found an increased risk of colorectal cancer in the highest versus the lowest quartile range of dairy intake (relative risk = 2.90, 95% confidence interval (CI): 1.26, 6.65) (10). Dairy products are the predominant source of calcium in the New Zealand diet. From 1937 to 1967, the government-funded milk-in-schools program provided 1 half-pint (284 mL) bottle of full-cream milk free each day to the majority of schoolchildren in New Zealand (11). The generations in New Zealand who participated in the milk-in-schools program were born from 1932 to 1962. Our a priori hypothesis for this national population-based, case-control study was that childhood dairy intake may be associated with the risk of developing colorectal cancer in adulthood. Historical records of the participation of children in the school milk program in

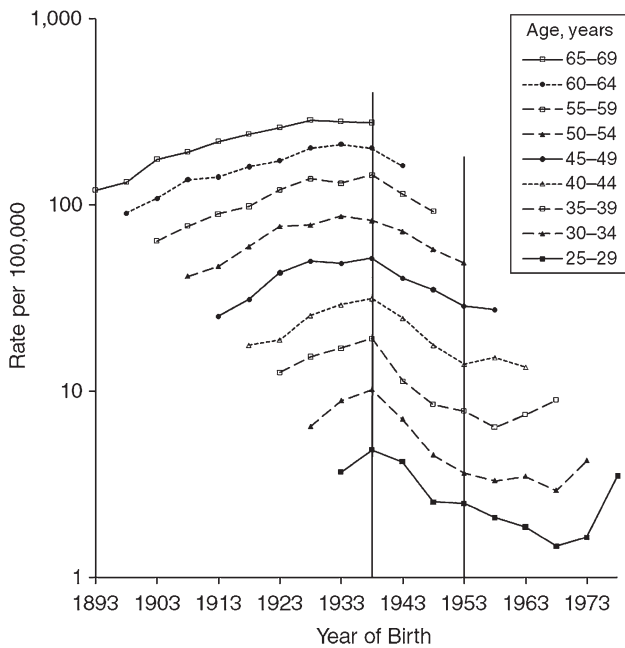


Figure 1. Incidence of colorectal cancer by age group and year of birth, New Zealand, 1958–2007. The vertical lines indicate the age-specific rates for the 1938 and 1953 birth cohorts.

New Zealand provided a unique opportunity to evaluate the hypothesis further.

MATERIALS AND METHODS

All people resident in New Zealand and newly diagnosed with colorectal cancer comprised the source population of cases. Inclusion in this population-based study required subjects to be listed on the electoral roll and to be aged 30–69 years. Older people were considered less likely to participate. Electoral registration is compulsory, and about 95% of adults are listed on the electoral roll. Approval for the study was obtained from the multiregional ethics committee of New Zealand, and subjects were invited to give consent and to complete a mailed questionnaire. For nonresponders, a second questionnaire was sent and, if no reply was received, the questionnaire was completed by telephone interview with trained interviewers.

Cases

The New Zealand Cancer Registry forwarded histology reports of colorectal cancer for all 831 patients living in New Zealand who were diagnosed between March 1, 2007, and November 30, 2007, and were aged 30–69 years. The reports were reviewed (M. J. S.), and the 27 people with carcinoma of the appendix or without confirmed adenocarcinoma of the colon or rectum were excluded. Approval to approach the patients was sought from each patient's doctor.

Data had to be collected from cases between 2 and 12 months after their diagnosis. Electoral roll listings were

found for 754 patients but, for 47 of these, notification or consent from their doctor was too delayed. Of the remaining 707 patients, 89 were unable to be approached as they were either dead or too ill, or their doctors advised against approaching them. Sixteen patients were unable to be traced, 31 declined the invitation to participate and, for 3 patients, language difficulties prevented participation. Six cases were excluded after data collection because they had previous colorectal cancer.

Controls

Control subjects were randomly selected from the electoral roll and frequency matched in 5-year age groups to the cases of colorectal cancer, for 800 people in all. Twenty-one controls were not living in New Zealand and were excluded. Of the 779 eligible controls, 31 declined the invitation to participate, 149 could not be traced, 7 were too ill to complete the questionnaire and, for 12, language difficulties prevented participation. Data for all control subjects were collected between January 2007 and April 2008. The mean time between diagnosis and the receipt of responses from the cases (5.1 months) was subtracted from the date of interview to create a reference date comparable to the diagnosis of the cases for the calculation of age. After interview, 7 controls with a previous diagnosis of colorectal cancer and 2 that were older than 69 years on their reference date were excluded.

Data collection

Subjects were sent a questionnaire by post with a reply-paid envelope. The questionnaire inquired about residential history prior to the age of 25 years, previous illnesses, the use of aspirin or dietary supplements in childhood, school milk participation and consumption, other childhood milk consumption, childhood dietary preferences, smoking, alcohol consumption before 25 years of age, screening tests for colorectal cancer, any family history of cancer, and sociodemographic characteristics. Questions about school milk consumption were prefaced by the statement, "For many years milk was provided free to some schools in New Zealand." Subjects were asked, "Did you drink the school milk?" "Approximately, how many half-pint bottles did you drink at school each week?" "At what age did you first drink school milk?" and "At what age did you stop drinking school milk?" Subjects were asked if, before 18 years of age, they followed a special diet because of religious reasons, allergies, diabetes, or were vegetarian, and they were asked what the dietary restriction was. No adult dietary or alcohol consumption data were collected. Childhood weight or height was not sought. The study hypothesis was disclosed to neither participants nor telephone interviewers.

Definition of terms

A positive family history of colorectal cancer was defined as having a sibling or parent with colorectal cancer. Educational attainment was defined as the highest qualification

gained and was categorized into 5 categories. Self-reported average monthly consumption of beer, wine, and spirits before 25 years of age was combined by using estimated alcohol contents of 3.5%, 12.5%, and 37.5%, respectively, and average alcohol consumption among drinkers was categorized into quintile ranges with cutpoints of 92, 232, 528, and 1,063 mL per month.

Self-identified ethnicity was sought by using the same question as the population census, whereby people select up to 3 ethnic groups. Each respondent was categorized into one of 3 ethnic groups by using the priority algorithm used by Statistics New Zealand (Maori first if listed, then "other," then New Zealand European ethnic groups). The "other" ethnic group comprised mainly Pacific and Asian peoples.

By using information on ever drinking milk at school, the numbers of bottles consumed a week (the intensity of consumption), and the ages of starting and stopping participation in school milk programs, as well as assuming a 40-week educational year, the total number of bottles consumed at school was calculated (categorized into none, 1–799, 800–1,199, 1,200–1,599, 1,600–1,799, and 1,800 or more bottles). The frequency (numbers of times a week) of consumption of cheese, milk drinks (excluding school milk), milk with cereals, yogurt, cream, custard, and other foods containing dairy products when subjects were aged 5–12 and 13–18 years was also sought by using questions from a previously validated adult food frequency questionnaire. These frequencies were summed to create an ordered semiquantitative variable grouped into 4 categories to rank the frequency of consumption of dairy products, other than school milk, at these ages. The amounts consumed were not sought, so calcium intake was not calculated.

External validation of exposure

Individual childhood diet is very difficult to validate but, as the milk was provided free in schools by the government, historical records of participation were available. This enabled group-level validation of the reports of school milk participation. In New Zealand, children usually start school on their fifth birthday. The participation in school milk programs of respondents who attended school in New Zealand before their 14th birthday was compared with contemporaneous published estimates of the proportion of pupils who participated. Many schools in the Southland region withdrew from the program in 1950 (12). The school milk drinking of Southland pupils was compared with that of pupils in all other regions, for which the government withdrew the program in 1967.

Statistical analysis

The prevalence of exposure to school milk in the pilot study was 70%. Using this estimate, we needed a sample size of at least 448 cases and 448 controls to attain 99% statistical power to detect a 50% or greater reduction in risk of colorectal cancer from participation in school milk programs with 95% confidence. The responses of the 562 cases and 571 controls were analyzed. Odds ratios and confidence

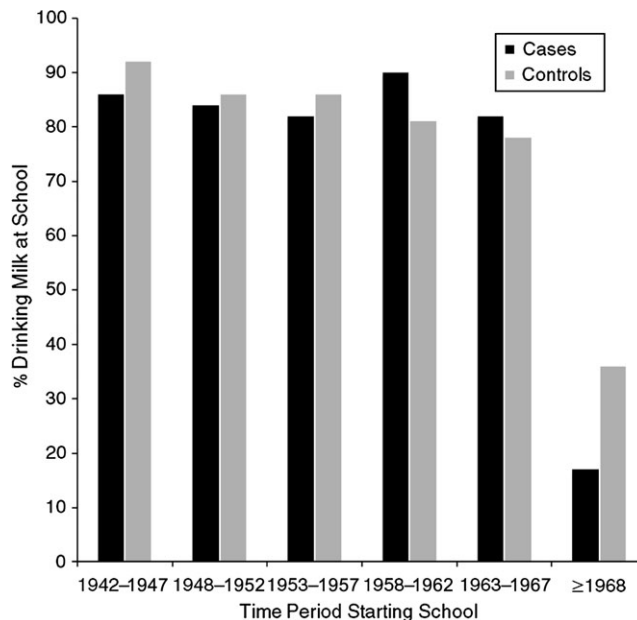


Figure 2. Participation in school milk programs by year of starting school for the 931 subjects living in New Zealand before the age of 14 years in the time period 1942–1982.

intervals were calculated by using multivariate unconditional logistic regression (13). Individual year of age at diagnosis, or age at reference date for controls, was fitted as a continuous variable in the regression models. Age, sex, ethnicity, and a family history of colorectal cancer were considered a priori to be associated with risk of colorectal cancer, so they were included in all regression models. Monotonic categorical variables were fitted as continuous variables to assess trends in odds ratios. When data for any variable in the regression model were missing, the record was excluded from the analysis. All *P* values are 2 sided.

RESULTS

Eighty-percent of eligible cases and 74% of eligible controls completed the questionnaire. Of these, 87% of cases and 78% of controls responded by mail, and 13% of cases and 22% of controls completed the questionnaire by telephone interview.

Validation of participation in school milk programs

For respondents starting school from 1942 to 1967, participation in school milk programs was between 82% and 90% for cases and between 78% and 92% for controls, whereas for those starting school from 1968 onward, participation was much lower (Figure 2). For people who started school in Southland from 1951 to 1967, 4 of 11 (36%) participants ever had school milk, significantly lower proportions than the 324 of 380 (85%) of their peers in the rest of New Zealand starting school during this period (*P* < 0.001).

For the 76 subjects at school in 1967 but not in Southland, 66% reported that school milk ceased between 1965 and 1968. For those born from 1937 to 1951 who participated in school milk programs and for whom the age at stopping school milk was available, 76 of 550 (14%) were 14 or more years of age and therefore at secondary school when milk stopped, whereas for generations born from 1952 to 1977, only 7 of 122 (6%) were of secondary school age when milk stopped ($P < 0.05$), representing the reduced participation of secondary schools over time.

Multivariate analysis

The average ages for cases and controls were 60.5 years and 60.8 years, respectively. As the controls were frequency matched by age, no significant change in odds ratio with increasing age was observed (Table 1). The adjusted odds ratio for colorectal cancer for those with, compared with those without, a reported family history of colorectal cancer was 1.46 (95% CI: 1.08, 1.96) and, for females compared with males, 0.81 (95% CI: 0.64, 1.02). Maori had a risk of colorectal cancer similar to that of New Zealand Europeans. The adjusted odds ratio for the association of other ethnicities with colorectal cancer compared with New Zealand Europeans was 0.63 (95% CI: 0.43, 0.93). No significant association was found for colorectal cancer with level of education, age at arrival in New Zealand, alcohol consumption before the age of 25 years, smoking status, or history of ulcerative colitis or Crohn's disease.

Drinking milk at school was reported on by 552 cases (98.2%) and 569 controls (99.6%). The adjusted odds ratio of colorectal cancer associated with ever drinking milk at school was significantly reduced (odds ratio (OR) = 0.70, 95% CI: 0.51, 0.96) (Table 2). The intensity of consumption was provided by 531 cases (94.5%) and 550 controls (96.3%), and a reduced adjusted odds ratio for 10 or more bottles drunk a week was found (OR = 0.39, 95% CI: 0.20, 0.77), but relatively few subjects drank more than 5 bottles a week. For 482 cases (85.8%) and 495 controls (86.7%), the total number of bottles consumed at school could be calculated, and a reduction in the odds ratios for colorectal cancer was observed with increasing total bottles of school milk drunk. This was statistically significant for 1,200–1,599 (OR = 0.62, 95% CI: 0.41, 0.93), 1,600–1,799 (OR = 0.57, 95% CI: 0.37, 0.90), and 1,800 or more bottles drunk (OR = 0.62, 95% CI: 0.41, 0.96) compared with none. The results were suggestive of a threshold effect at about 1,200–1,599 bottles drunk. When the total number of school milk bottles consumed was included in multivariate logistic regression as a continuous variable, a 2.1% decrease in the risk of colorectal cancer was associated with each additional 100 bottles of milk consumed (OR = 0.979, 95% CI: 0.965, 0.993). When consumption was modeled by using the intensity of consumption and the number of years of consumption separately, a statistically significant trend of decreasing odds ratios with increasing intensity of consumption (OR = 0.924 per bottle a week, 95% CI: 0.854, 0.999), but not for the number of years of consumption (OR = 0.985 per year of consumption, 95% CI: 0.939, 1.034), was found. The results were not significantly altered after additional

adjustment for the method of data collection (mail or telephone). Exclusion of participants who received schooling only in Southland or those reporting low-dairy diets in childhood because of allergy or other reasons did not appreciably alter the results.

A significant reduction in the risk of colorectal cancer with increasing frequency of consumption of dairy products other than school milk from the ages of 5–12 years was observed ($P < 0.05$) but not from ages 13–18 years (Table 2). Concurrent adjustment for the frequency of consumption of dairy products from ages 5–12 years, 13–18 years, or 5–18 years did not appreciably alter the odds ratios observed for drinking school milk, intensity of school milk consumption, or total number of school milk bottles consumed (Table 3). Lower odds ratios of colorectal cancer were again found with increasing frequency of consumption of dairy products before age 13 years compared with consumption between 13 and 18 years of age, but these odds ratios were not statistically significant, and no statistically significant trends in either of these odds ratios were found.

The associations with colorectal cancer of participation in school milk programs, the intensity of consumption of school milk, and the total number of milk bottles drunk were also evaluated as continuous variables for particular subgroups (Table 4). The odds ratios were less than 1 for each measure of school milk consumption for most groups studied. Significantly reduced adjusted odds ratios were found for all 3 measures of school milk consumption for those without a history of ulcerative colitis or Crohn's disease and for those born in New Zealand.

For the intensity of consumption and the total number of milk bottles drunk, statistically significant reductions in the odds ratios of colorectal cancer were found for men, those aged 60–69 years at diagnosis or reference date, those of European ethnicity, both those with or without a family history of colorectal cancer, those whose schooling was not solely in Southland, and those who returned the questionnaire by post. For women, the odds ratio for colorectal cancer was significantly reduced with increasing intensity of school milk consumption but not total milk bottles drunk.

The observed reduction in the odds of colorectal cancer with participation in school milk programs, for each extra bottle a week consumed or for each 100 bottles of school milk drunk, was also present when those who had a fecal occult blood test, a sigmoidoscopy or colonoscopy 12 or more months before their reference date, a prescription for aspirin during childhood for more than 1 month, or calcium supplementation during childhood were excluded (data not shown).

DISCUSSION

This national population-based, case-control study provides evidence that school milk consumption was associated with a reduction in the risk of adult colorectal cancer in New Zealand. Furthermore, a dose-dependent relation was evident.

Milk was not commonly considered a drink before the milk-in-schools program started in 1937, even on farms in New Zealand (14). By 1939, it was estimated that, of the

Table 1. Characteristics of Colorectal Cancer Cases and Controls Aged 30–69 Years in 2007 and Living in New Zealand

Characteristic	No. of Cases	No. of Controls	Unadjusted OR for Colorectal Cancer	95% CI	Adjusted OR for Colorectal Cancer ^a	95% CI
Age (individual years)	562	571	1.00	0.98, 1.01	0.99	0.98, 1.01
Family history of colorectal cancer						
No	433	476	1.00		1.00	
Yes	129	95	1.49**	1.11, 2.01	1.46*	1.08, 1.96
Sex						
Male	302	276	1.00		1.00	
Female	260	295	0.81	0.64, 1.02	0.81	0.64, 1.02
Ethnicity						
New Zealand Europeans	472	455	1.00		1.00	
Maori	42	41	0.99	0.63, 1.55	1.01	0.64, 1.59
Other	48	75	0.62*	0.42, 0.91	0.63*	0.43, 0.93
Education ^b						
No post-primary school qualification	173	176	1.00		1.00	
Basic vocational qualification	84	107	0.80	0.56, 1.14	0.84	0.58, 1.20
Intermediate vocational qualification	44	45	1.00	0.63, 1.58	0.97	0.61, 1.55
Advanced vocational qualification	159	146	1.11	0.82, 1.51	1.08	0.79, 1.48
Degree or diploma	83	80	1.06	0.73, 1.53	1.06	0.72, 1.55
Arrival in New Zealand						
Arrived at age 14 or more years	90	104	1.00		1.00	
Arrived before age 14 years	15	21	0.83	0.40, 1.70	0.71	0.34, 1.48
Born in New Zealand	457	446	1.18	0.87, 1.62	0.88	0.60, 1.30
Alcohol before age 25 years, mL/month						
None	118	127	1.00		1.00	
<92	77	99	0.84	0.57, 1.24	0.82	0.55, 1.21
92–232	92	87	1.14	0.77, 1.67	1.04	0.70, 1.54
233–528	95	84	1.22	0.83, 1.79	1.05	0.70, 1.58
529–1,063	85	91	1.01	0.68, 1.48	0.82	0.53, 1.26
>1,063	95	83	1.23	0.84, 1.81	1.01	0.65, 1.56
Smoking						
Never smoked	262	267	1.00		1.00	
Past smoker	249	231	1.10	0.86, 1.41	1.06	0.82, 1.36
Current smoker	51	73	0.71	0.48, 1.06	0.69	0.46, 1.03
History of ulcerative colitis or Crohn's disease						
No	549	561	1.00		1.00	
Yes	13	10	1.33	0.58, 3.06	1.29	0.56, 3.00

Abbreviations: CI, confidence interval; OR, odds ratio.

* $P < 0.05$; ** $P < 0.01$.

^a Adjusted by individual year of age, sex, ethnicity, and family history of colorectal cancer in logistic regression, where appropriate.

^b Available for 541 cases and 553 controls.

65% of schools participating, 85% of children were drinking school milk daily (15), reaching 88% by 1950 and with participation in some regions as high as 98% (16). The participation of secondary school pupils was lower and de-

creased after 1945. The proportions of subjects participating and the years they reported that school milk stopped corresponded closely to the historical records. Earlier generations reported stopping school milk at older ages than later

Table 2. Consumption of School Milk and Dairy Products and Odds Ratios for Colorectal Cancer Among Cases and Controls Aged 30–69 Years in 2007 and Living in New Zealand

Characteristic	No. of Cases	No. of Controls	Unadjusted OR for Colorectal Cancer	95% CI	Adjusted OR for Colorectal Cancer ^a	95% CI
School milk ^b						
No	122	103	1.00		1.00	
Yes	430	466	0.78	0.58, 1.04	0.70*	0.51, 0.96
School bottles consumed per week ^c						
None	122	103	1.00		1.00	
1–4	55	44	1.06	0.66, 1.70	0.96	0.59, 1.56
5	320	353	0.77	0.57, 1.04	0.68*	0.49, 0.95
6–9	18	19	0.80	0.40, 1.60	0.70	0.34, 1.43
10 or more	16	31	0.44*	0.23, 0.84	0.39**	0.20, 0.77
<i>P</i> _{trend}				0.008		0.002
Total school bottles consumed ^d						
None	122	103	1.00		1.00	
1–799	67	50	1.13	0.72, 1.78	1.04	0.66, 1.67
800–1,199	65	59	0.93	0.60, 1.44	0.81	0.51, 1.29
1,200–1,599	89	108	0.70	0.47, 1.02	0.62*	0.41, 0.93
1,600–1,799	62	79	0.66	0.43, 1.01	0.57*	0.37, 0.90
1,800 or more	77	96	0.68	0.46, 1.01	0.62*	0.41, 0.96
<i>P</i> _{trend}				0.005		0.002
Consumption of dairy products at ages 5–12 years, frequency per week ^e						
0–9	82	69	1.00		1.00	
10–19	185	181	0.86	0.59, 1.26	0.74	0.50, 1.10
20–29	141	162	0.73	0.50, 1.08	0.62*	0.41, 0.93
≥30	42	56	0.63	0.38, 1.05	0.51*	0.30, 0.87
<i>P</i> _{trend}				0.039		0.005
Consumption of dairy products at ages 13–18 years, frequency per week ^f						
0–9	105	91	1.00		1.00	
10–19	207	210	0.85	0.61, 1.20	0.77	0.54, 1.10
20–29	113	125	0.78	0.54, 1.14	0.70	0.47, 1.03
≥30	34	37	0.80	0.46, 1.37	0.70	0.40, 1.21
<i>P</i> _{trend}				0.232		0.087

Abbreviations: CI, confidence interval; OR, odds ratio.

* $P < 0.05$; ** $P < 0.01$.

^a Adjusted by individual year of age, sex, ethnicity, and family history of colorectal cancer in logistic regression.

^b Available for 552 cases and 569 controls.

^c Available for 531 cases and 550 controls.

^d Available for 482 cases and 495 controls.

^e Available for 450 cases and 468 controls.

^f Available for 459 cases and 463 controls.

generations, corresponding to the report that, by 1959, only about 10% of secondary school children were drinking school milk (12). As predicted from historical records, lower participation of children schooled in Southland from 1951 onward was also found. Although the frequency of consumption of milk products outside school was collected,

a quantitative estimate of childhood consumption was not available to allow calcium consumption to be estimated.

The study included all histologically confirmed cases of colorectal cancer in New Zealand over a predefined time period. Cases for this study came from the entire population through statutory notification of cancers by all pathology

Table 3. Odds Ratios for Variables in Logistic Regression Models That Included the Consumption of Milk Products Other Than School Milk Among Colorectal Cancer Cases and Controls Aged 30–69 Years in 2007 and Living in New Zealand

Characteristic	Model 1				Model 2			
	OR ^a	95% CI	OR ^a	95% CI	OR ^b	95% CI	OR ^b	95% CI
School milk								
No	1.00		1.00					
Yes	0.73	0.50, 1.05	0.72	0.50, 1.04				
Total milk bottles consumed (per 100 bottles)					0.984*	0.967, 1.000	0.983*	0.966, 1.000
Age	0.99	0.97, 1.01	0.99	0.97, 1.01	0.99	0.97, 1.01	0.99	0.97, 1.01
Sex								
Male	1.00		1.00		1.00		1.00	
Female	0.81	0.62, 1.06	0.80	0.61, 1.05	0.87	0.65, 1.16	0.86	0.64, 1.16
Ethnicity								
New Zealand European	1.00		1.00		1.0		1.00	
Maori	1.00	0.60, 1.65	0.99	0.60, 1.62	1.17	0.69, 2.01	1.15	0.67, 1.96
Other	0.49*	0.31, 0.79	0.49*	0.31, 0.78	0.54*	0.34, 0.88	0.55*	0.34, 0.88
Family history of colorectal cancer								
No	1.00		1.00		1.00		1.00	
Yes	1.65*	1.17, 2.31	1.65*	1.17, 2.31	1.84*	1.28, 2.66	1.83*	1.27, 2.64
Consumption of dairy products at ages 5–12 years, frequency per week								
0–9	1.00				1.00			
10–19	0.89	0.50, 1.58			0.87	0.46, 1.63		
20–29	0.77	0.41, 1.45			0.80	0.40, 1.60		
≥30	0.57	0.26, 1.25			0.56	0.24, 1.30		
<i>P</i> _{trend}		0.137				0.194		
Consumption of dairy products at ages 13–18 years, frequency per week								
0–9	1.00				1.00			
10–19	0.89	0.53, 1.50			0.97	0.55, 1.71		
20–29	0.92	0.51, 1.67			0.96	0.50, 1.83		
≥30	0.99	0.44, 2.25			0.97	0.41, 2.29		
<i>P</i> _{trend}		0.980				0.919		
Total consumption of dairy products at ages 5–18 years, frequency per week								
0–9			1.00				1.00	
10–19			0.67*	0.45, 1.00			0.74	0.47, 1.15
20–29			0.78	0.51, 1.20			0.85	0.53, 1.37
≥30			0.47*	0.26, 0.87			0.45*	0.23, 0.87
<i>P</i> _{trend}				0.108				0.135

Abbreviations: CI, confidence interval; OR, odds ratio.

* $P < 0.05$.

^a Available for 433 cases and 452 controls. Regression model 1 consists of the variables listed.

^b Available for 378 cases and 402 controls. Regression model 2 consists of the variables listed.

laboratories. Response rates for both cases and controls were high, minimizing the possible effects of selection bias. Exposure information bias was avoided because neither case nor control subjects, nor telephone interviewers, were made aware of the hypothesis under study.

The consistency of the reduction in odds ratios for the association with colorectal cancer across subgroups reduces the likelihood that residual confounding from these factors is an explanation for the results obtained. Exclusion of those with low-dairy diets due to allergy or other reasons

Table 4. Odds Ratios^a for Colorectal Cancer From Participation in School Milk Programs for Different Subgroups Among Cases and Controls Aged 30–69 Years in 2007 and Living in New Zealand

Subgroup	OR for Ever Vs. Never Having School Milk ^b	95% CI	OR for Amount of School Milk Drunk/Week ^c	95% CI	OR for Colorectal Cancer/100 Bottles Drunk ^d	95% CI
Age at diagnosis or reference date, years						
30–49	0.84	0.33, 2.10	0.964	0.808, 1.151	1.013	0.947, 1.084
50–59	1.03	0.57, 1.87	1.020	0.927, 1.122	0.993	0.965, 1.022
60–64	0.79	0.41, 1.53	0.944	0.853, 1.045	0.986	0.957, 1.016
65–69	0.66	0.36, 1.21	0.895**	0.825, 0.972	0.976*	0.955, 0.998
Sex						
Male	0.70	0.43, 1.13	0.922*	0.866, 0.983	0.977*	0.960, 0.995
Female	0.70	0.46, 1.08	0.922*	0.856, 0.994	0.979	0.956, 1.003
Ethnicity						
New Zealand European	0.73	0.51, 1.05	0.921**	0.871, 0.974	0.976**	0.959, 0.993
Maori	0.45	0.09, 2.26	0.954	0.797, 1.143	0.988	0.941, 1.037
Other	0.59	0.27, 1.30	0.925	0.820, 1.043	0.983	0.951, 1.017
Family history of colorectal cancer						
No	0.75	0.53, 1.08	0.938*	0.889, 0.989	0.983*	0.967, 0.998
Yes	0.53	0.27, 1.04	0.878*	0.783, 0.985	0.962*	0.929, 0.995
History of ulcerative colitis or Crohn's disease						
No	0.70*	0.51, 0.97	0.930**	0.886, 0.977	0.981**	0.967, 0.995
Yes	0.86	0.08, 8.94	0.732	0.492, 1.089	0.826	0.680, 1.002
Arrival in New Zealand						
Arrived at age 14 or more years	0.94	0.49, 1.80	0.985	0.895, 1.085	0.996	0.970, 1.022
Arrived before age 14 years	0.57	0.07, 4.69	1.000	0.648, 1.541	0.992	0.874, 1.127
Born in New Zealand	0.65*	0.45, 0.95	0.908***	0.857, 0.961	0.972***	0.955, 0.989
Schooled only in Southland						
No	0.75	0.53, 1.04	0.934**	0.889, 0.980	0.981**	0.967, 0.995
Yes	0.24	0.01, 4.18	0.825	0.452, 1.506	0.927	0.747, 1.151
Method of data collection						
Mail	0.75	0.53, 1.07	0.934*	0.886, 0.984	0.980*	0.965, 0.995
Telephone	0.62	0.27, 1.41	0.923	0.811, 1.051	0.983	0.946, 1.022

Abbreviations: CI, confidence interval; OR, odds ratio.

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

^a As appropriate, odds ratios were adjusted by individual year of age, sex, ethnicity, and family history of colorectal cancer in logistic regression.

^b Available for 552 cases and 569 controls.

^c Available for 531 cases and 550 controls and amount drunk per week fitted as a continuous variable.

^d Available for 482 cases and 495 controls and numbers of bottles drunk fitted as a continuous variable.

did not alter the findings. For confounding from adult exposures to occur, the consumption of milk in the nationally supplied free school milk programs would need to be correlated with adult exposures, such as adult diet. We consider it unlikely that the factors in adulthood that alter the risk of colorectal cancer are associated with school milk consumption, as formal exemption of pupils from the school milk program was required. Furthermore, some of the previously reported associations of colorectal cancer

with aspects of adult diet might be mediated through childhood rather than adult diet.

Several studies have reported that adult calcium (6, 17–19), milk, or dairy food consumption (20) can prevent colorectal cancer or adenomas, but a role in childhood has seldom been assessed. Each half-pint bottle contained approximately 360 mg of calcium, and the estimated average requirement of calcium in boys and girls 4–8 years of age and 9–11 years of age is, respectively, 520 mg and 800 mg

per day. However, components in full-cream milk other than calcium or possibly fermentation of milk by lactobacillus (21) may have contributed to the lowered risk of colorectal cancer observed.

School milk was provided through subsidized schemes in many other countries about the same time as the scheme in New Zealand. For example, milk was part of the school lunch program introduced to elementary schools in the United States in 1946, and a subsidized scheme for children aged 7–11 years was introduced nationwide in the United Kingdom in 1934, with 56% participating by the start of World War II (21) and ending in 1971. In Australia, a free scheme of one-third pint bottles was introduced nationwide in 1953. Comparisons of childhood milk consumption and incidence of colorectal cancer in different cohorts in these countries are needed to see whether effects similar to those observed in New Zealand are present. Differences in the childhood consumption of milk might also contribute to the maintenance of the colorectal cancer risk from their country of origin in migrants between England and Wales, and New Zealand (22).

Our results are contrary to those of the cohort study in the United Kingdom that imputed the individual consumption of dairy foods from 1-week household food records in childhood but did not incorporate school milk consumption. It found an increased risk of colorectal cancer with increased household dairy intake in childhood (10). Compared with the predominantly soft water in New Zealand, the hard water supply in most of the United Kingdom contains considerable calcium, and this additional source of dietary calcium may be important. The ingestion of food concurrently with milk can affect calcium absorption (23), and school milk consumption might have been advantageous because it was often consumed without food.

Our results suggest that regular daily consumption of milk in childhood may reduce colorectal cancer incidence, possibly by the action of calcium on the development of adenoma. Further etiologic studies of colorectal cancer should examine the effects of childhood milk consumption or calcium intake, and childhood diet overall, in addition to adult diet. In addition, the biologic mechanisms by which childhood milk consumption may reduce risk of colorectal cancer should be explored.

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