THE VITAMIN A STATUS OF SCHOOL CHILDREN IN FIVE NORTHERN MANITOBA NATIVE COMMUNITIES

by

LORETTA A. BOGERT-O'BRIEN

A thesis submitted in partial fulfillment
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ABSTRACT

Seventy-two grade 4 children and 71 grade 6 children from five northern Manitoba communities were involved in a study to determine if indicators of vitamin A status varied among the communities and if the distribution of a school food supplement had an effect on the indicators. The basic component of the supplement was a milk product. Four dietary indicators of vitamin A status based on 24-hour recall data; one biochemical indicator, serum vitamin A; and two clinical indicators based on a rapid dark adaptation test were used.

No evidence of vitamin A deficiency was suggested by the biochemical or clinical indicators, however, the dietary data suggested that some children may have been at risk of vitamin A deficiency. The diets of the children could have been improved at the time of the study, with dietary quality apparently being related to the vitamin A concentrations of foods chosen, rather than the total amount of food consumed.

No significant differences were found among the communities of Barrows Junction, Cormorant Lake, Moose Lake, and Brochet for any of the intake variables. The mean vitamin A density of the diets in Crane River was significantly lower than those in all other communities, and the values for the other three intake variables in Crane River were significantly

lower than those in Moose Lake and/or Brochet. There did not seem to be a simple relationship between the degree of isolation of the communities and the intakes of vitamin A. No differences were found among the communities for either the biochemical or clinical indicators of vitamin A status.

No significant differences were found in the vitamin A intake variables or the serum vitamin A levels between those children who received the school supplement and those who did not. The findings for the dark adaptation test variables were counterintuitive. Grade 4 children (those who regularly received the school supplement) took significantly longer to perform the test than the grade 6 children (those who did not regularly receive the supplement), suggesting that age may be a confounding variable which needs to be controlled for when using the rapid dark adaptation test.

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LITERATURE REVIEW

Introduction

Prior to contact with European immigrants, the native peoples of Canada lived on the natural resources surrounding them and were thought to be relatively free of disease (Schaefer, 1978). However, within the last few centuries, changes in their lifestyle and health status have been rapid, often with apparently detrimental effects (Bruyere, 1981; Graham-Cumming, 1967; and Schaefer, 1978).

Diseases such as smallpox, measles, and tuberculosis, which caused widespread death among native Canadians after their initial contact with the European settlers, no longer pose the same threat today (Graham-Cumming, 1967; and Schaefer, 1978). However, there are other health problems which are of major concern.

Many investigators have reported high incidences of diseases of the respiratory and gastrointestinal tracts as well as other infectious and parasitic diseases among Canadian Indian populations (Blouw et al., 1973; Bruyere, 1981; DIAND, 1980; Ellestad-Sayed et al., 1979; Evers and Rand, 1983; Longstaffe et al., 1982; and Young, 1982). Infectious diseases were listed as the major cause of infant deaths among Indians, with overall infant death rates 1.5 to 2 times the non-Indian rates in Manitoba (Bruyere, 1981) and Canada (DIAND, 1980).

It was suggested that the higher incidences of Indian infant deaths due to infectious diseases reflected poorer living conditions, lack of sewage disposal and potable water, as well as poorer access to medical services (DIAND, 1980). Nutritional status may also play a role in altering susceptibility to infections. Deficiencies of a number of nutrients have been reported to be related to an impaired immune response in humans and experimental animals (Axelrod, 1980). Additionally, in specific reference to vitamin A, concurrent occurences of vitamin A deficiency and infections have been reported frequently in humans (WHO et al., 1982). Ellestad-Sayed and coworkers (1979) found that breast-feeding protected against infections in Indian infants, thus recommended its promotion.

Schaefer (1978) reported that there have been increases in the incidences of so-called "diseases of civilization," such as obesity, gallstones, acne, diabetes, hypertension, and atherosclerosis, among native populations since their contact with European immigrants. He suggested that changes to more sedentary lifestyles and diets higher in fat and rapidly absorbable carbohydrates were contributory factors. Poor dental health has also been widely documented among native populations (Birkbeck et al., 1971; Blouw et al., 1973; Schaefer, 1978; and Young, 1982).

Relationships between nutritional status and clinically observable disease states are often difficult to ascertain and seldom exist exclusive of other factors. However, the above-mentioned studies indicated that the suboptimal health status of native Canadians may be partially related to diet. This was also borne out by the Nutrition Canada Survey, during which no clinical signs were found that could be attributed to poor nutritional status, except obesity. Yet the dietary and biochemical measurements indicated that there were risks of deficiencies in iron, folate, vitamin C, vitamin A, vitamin D, and calcium amongst native Canadians (Bureau of Nutritional Sciences, 1975a).

Dietary Intakes of Vitamin A

Few studies have reported data on the vitamin A status of persons of Indian ancestry in Manitoba. The majority of the studies included in this review were carried out in regions across Canada. Several studies from Montana and the Dakotas were also included since they reported dietary habits of native people similar to those observed in Manitoba.

Several methods of dietary data collection were employed in the studies cited to estimate food consumption. The most objective type quantified food intakes through the use of dietary recalls, records, or histories. Other methods included estimations of the per capita availability of vitamin A from food disappearance data, measurements of food group consumption frequencies, and descriptions of food consumption patterns.

The authors of the studies which quantified vitamin A intakes presented their data using different values for recommended intakes, making comparisons of the data difficult. Values were expressed either in international units (IU) or retinol equivalents (RE) and Table 1 shows the range of recommended intakes suggested by several expert committees.

Since the purification of retinol, it is possible to express vitamin A activity in retinol equivalents. The use of international units overestimates the availability of vitamin A activity from carotenes to humans. To convert international units of vitamin A to retinol equivalents the following equation is used:

$$RE = \frac{\text{IU retinol}}{3.33} + \frac{\text{IU B-carotene}}{10}$$

Table 1. Variations in recommended daily vitamin A intakes.

Age	Sex	Canada 1983	Canada 1964	United States 1980	United States 1968	FAO/WHO 1967	Nutrition Canada 1975
4-6 yr	M&F	500[a]	1000[b] (200)[c]	500[a]	2500[b] (500)[c]	300[a]	20[d]
7-9 yr	M&F	700	1500 (300)	700	3500 (700)	400	"
10 yr	M&F	800	2000 (400)	"	"	575	"
11-12 yr	F	"	"	800	4500 (900)	"	"
	M	"	"	1000	"	"	"
13-15 yr	F	"	2700 (540)	800	5000(1000)	725	750[a]
	M	900	"	1000	"	"	"
16-18 yr	F	800	3200 (640)	800	"	750	"
	M	1000	"	1000	"	"	"
19+ yr	F	800	3700 (740)	800	"	"	"
	M	1000	"	1000	"	"	"

[a]Retinol equivalents.

[b]International units.

[c]Corresponding retinol equivalents if it is assumed that the international units are provided equally by retinol and carotene.

[d]Retinol equivalents/kg body weight.

Sources: Bureau of Nutritional Sciences, 1983 and 1975b; Health and Welfare Canada, 1964; Food and Nutrition Board, 1980, 1974, 1968 and 1964; Joint FAO/WHO Expert Group, 1967; and Bureau of Nutritional Sciences, 1975a.
(Note: The 1975 Canadian recommendations were similar to those for 1983, and the 1974 and 1964 United States recommendations were similar to those for 1980 and 1968, respectively.)

For ease in conversion it is assumed that in Canadian diets animal products contribute only retinol and plant products only B-carotene (Bureau of Nutritional Sciences, 1983).

In both the 1964 edition of the Dietary Standard for Canada (Health and Welfare Canada, 1964) and the 1968 edition of the Recommended Dietary Allowances for the United States (Food and Nutrition Board, 1968) it was assumed that half of the vitamin A activity (expressed in international units) in the average North American diet came from carotenes and half from retinol. This assumption has been supported by several studies. Canadian disappearance data quoted by the Canadian Dietary Standards committees showed that carotenes provided 52% (Health and Welfare Canada, 1964) and 58% (Bureau of Nutritional Sciences, 1975b) of available vitamin A when expressed in international units. Data from the United States indicated that 47% of the vitamin A in average diets was supplied from the provitamin (Food and Nutrition Board, 1968).

Lee and coworkers (1971) found that two British Columbia Indian populations had vitamin A intakes of which 57 and 63%, respectively, were provided by carotene. However, the majority of the researchers investigating dietary intakes of native populations in Canada reported lower percentages supplied by the provitamin: between 47 and 50% of the total vitamin A when expressed in international units (Bureau of Nutritional Sciences, 1977; Ellestad-Sayed et al., 1981; and Stepien, 1978).

Although the compositions of vitamin A intakes in the diets of different groups vary, carotenes and retinol generally contribute equally to the total vitamin A activity when expressed in international units. Using this assumption of equal contributions, older recommended vitamin A intakes, which were expressed in international units, can be converted to retinol equivalents for comparison to present recommendations. The corresponding values in retinol equivalents for the 1964 Canadian recommendations are lower than those currently in use, whereas conversions of the 1968 United States recommendations are similar to present recommended intakes (Table 1).

Table 2 shows the results of dietary studies that quantified vitamin A intakes through the use of dietary records, recalls, or histories. In each case the mean or median intake for a group of individuals was compared to the recommended intake, and usually the percentage of individuals with intakes below the recommended intake was recorded.

Anderson and coworkers (1982) found that the comparison of the mean intake of a group of individuals to the recommended intake resulted in an underestimation of the risk of nutrient

Table 2. Results of dietary studies which quantified vitamin A intakes.

Researchers	Sample Description Location	Age	Sex	n	Mean ($\bar{x}$) or Median (md) Intake	Percent < Specified Level	Recom. Nutrient Intake Used	Comments
Ellestad-Sayed et al., 1981	Cross Lake, Man.	$\bar{x}$=35 mo	M&F	79	md=150% of RNI	25% < RNI	400-500 RE	-RNI assumed from Bur. Nutr. Sci., 1975b
	Garden Hill, Man.	$\bar{x}$=35 mo	M&F	72	md=135% of RNI	30% < RNI	400-500 RE	
Haworth et al., 1976	Winnipeg Children's Hospital (mainly urban)	1-5 mo	M&F	16	md=85% of RNI	70% < RNI	400 RE	-% values estimated from bar graphs -RNI assumed from Bur. Nutr. Sci., 1975b
		6-11 mo	M&F	16	md=170% of RNI	10% < RNI	400 RE	
		1-5 yr	M&F	71	md=190% of RNI	20% < RNI	400-500 RE	
Bur. Nutr. Sci., 1975a	Nutrition Canada Indian Popn. (across Canada)	5-9 yr	M&F	241	md=656 RE	36% < 500 RE	500-700 RE	-% values calculated from intake distribution tables -RNI from Bur. Nutr. Sci., 1983
		10-19 yr	F	270	md=583 RE	63% < 750 RE	800 RE	
		10-19 yr	M	203	md=749 RE	51% < 750 RE	800-900 RE	
	Nutrition Canada National Popn. (across Canada)	5-9 yr	M&F	1351	md=904 RE	19% < 500 RE	500-700 RE	
		10-19 yr	F	1472	md=775 RE	48% < 750 RE	800 RE	
		10-19 yr	M	1410	md=1050 RE	29% < 750 RE	800-900 RE	
Gillis, 1976	11 Northern Sask. Communities	5-14 yr	F	34	$\bar{x}$=640 RE	----	700 RE	
		5-14 yr	M	26	$\bar{x}$=630 RE	----	750 RE	
Lee et al., 1971	Anaham, B.C.	6-9 yr	M&F	29	$\bar{x}$=2970 IU	45% < 2/3 RNI	1500 IU	
		9-13 yr	M&F	27	$\bar{x}$=3123 IU	33% < 2/3 RNI	2000 IU	
		13-20 yr	F	18	$\bar{x}$=2124 IU	72% < 2/3 RNI	3000 IU	
		13-20 yr	M	13	$\bar{x}$=2320 IU	54% < 2/3 RNI	3000 IU	
	Ahousat, B.C.	6-9 yr	M&F	30	$\bar{x}$=4748 IU	0% < 2/3 RNI	1500 IU	
		9-13 yr	M&F	32	$\bar{x}$=5818 IU	9% < 2/3 RNI	2000 IU	
		13-20 yr	F	11	$\bar{x}$=4500 IU	36% < 2/3 RNI	3000 IU	
		13-20 yr	M	6	$\bar{x}$=5884 IU	17% < 2/3 RNI	3000 IU	
Stepien, 1978	4 Isolated B.C. Reserves	5-9 yr	M&F	14	$\bar{x}$=3301 IU	7% < 2/3 RNI	1000-1500 IU	-RNI assumed from Health and Welfare Canada, 1964
		10-19 yr	F	15	$\bar{x}$=2532 IU	27% < 2/3 RNI	2000-3200 IU	
		10-19 yr	M	11	$\bar{x}$=2176 IU	36% < 2/3 RNI	2000-3200 IU	
	3 Non-isolated B.C. Reserves	5-9 yr	M&F	17	$\bar{x}$=3323 IU	0% < 2/3 RNI	1000-1500 IU	
		10-19 yr	F	10	$\bar{x}$=3275 IU	30% < 2/3 RNI	2000-3200 IU	
		10-19 yr	M	14	$\bar{x}$=4986 IU	7% < 2/3 RNI	2000-3200 IU	

Table 2. (continued)

Researchers	Sample Description Location	Age	Sex	n	Mean ($\bar{x}$) or Median (md) Intake	Percent < Specified Level	Recom. Nutrient Intake Used	Comments
Dong and Feeney, 1968	Alert Bay, B.C. Indian Popn.	9-14 yr	M&F	34	$\bar{x}$=629 IU	----	1500-2700 IU	-RNI assumed from Health and Welfare Canada, 1964
	Alert Bay, B.C. Non-Indian Popn.	9-14 yr	M&F	27	$\bar{x}$=916 IU	----	1500-2700 IU	
Johnston et al., 1977	Shubenacadie, N.S. Indian Popn.	15-50 yr	F	120	md=3703 IU	49% < RNI	3700 IU	
	Shubenacadie, N.S. Caucasian Popn.	15-50 yr	F	115	md=4664 IU	34% < RNI	3700 IU	
ICNND, 1964a	Fort Belknap Reservation (N. Central Montana)	10-12 yr	F	10	$\bar{x}$=1682 IU	----	4500 IU	
		10-12 yr	M	18	$\bar{x}$= 465 IU	----	4500 IU	
		13-15 yr	F	7	$\bar{x}$=2848 IU	----	5000 IU	
		13-15 yr	M	10	$\bar{x}$=2924 IU	----	5000 IU	
ICNND, 1964b	Blackfeet Reservation (N.W. Montana)	10-12 yr	F	22	$\bar{x}$=1955 IU	----	4500 IU	
		10-12 yr	M	24	$\bar{x}$=1628 IU	----	4500 IU	
		13-15 yr	F	12	$\bar{x}$=2570 IU	----	5000 IU	
		13-15 yr	M	17	$\bar{x}$=2476 IU	----	5000 IU	
Bass and Wakefield, 1974	Standing Rock (The Dakotas)	19-75 yr	F	94	$\bar{x}$=4635 IU	64% < 3/4 RNI	5000 IU	

deficiency among members of the group, whereas the calculation of the percentage of individuals consuming less than the recommended intake overestimated the risk of deficiency. They suggested a method of calculating the number of "true deficients" which took account of both the variations in intakes and requirements of individuals. The studies reviewed did not present the latter calculation and it is assumed that the risk of vitamin A deficiency for each study population was between the level suggested by the mean or median, and the percentage of individuals consuming an amount of vitamin A less than the recommended intake.

The first two studies presented in Table 2 were carried out among Manitoba preschool Indian children. Ellestad-Sayed and coworkers (1981) presented data from children in Cross Lake and Garden Hill, two northern communities accessible only by plane. The other study involved children who were outpatients at Winnipeg Children's Hospital. The sample consisted mainly of urban Indian children, but some came from rural areas. Children attending a hospital outpatient clinic cannot be considered representative of the general population, however, children with severe acute illnesses or dehydration, or those who had been hospitalized or in foster home care within the last three months were not included in the study (Haworth et al., 1976).

The median intakes suggested that the vitamin A intakes were adequate among these populations since, except for one group studied, all values were above the recommended levels. However, there were between 10 and 30% of the children who did not consume the recommended amount of vitamin A in the groups where the median intakes were above the recommended levels, and in the group whose median intake was below the recommended intake, 70% of the children had intakes below the recommendation.

The Nutrition Canada Indian sample was comprised of persons from 29 reserves belonging to six cultural groupings in the provinces and territories. Three locations in Manitoba were included. Some of the reserves were close to urban centres and others were isolated. The National sample was made up of residents of the 10 provinces, excepting Indians on reserves and persons living in institutions and military camps. Individuals from rural, urban, and metropolitan areas were included (Bureau of Nutritional Sciences, 1975a).

The median intake for the 5 to 9 year old Indian population was comparable to the recommended intake for that age group, however, both the female and male Indian populations aged 10 to 19 years had median intakes lower than the recommended levels. Each median intake for the Indian population groups was lower than that for the same age and sex group in the national sample, plus greater percentages of Indian children had intakes below levels similar to the Canadian recommendations (Bureau of Nutritional Sciences, 1975a and 1983).

Gillis (1976) presented data from 11 northern Saskatchewan communities which differed with respect to their access to food and levels of medical and media services. Data from all communities were pooled for the discussion of nutrient intakes by the various age and sex groups. Girls and boys aged 5 to 14 years had mean vitamin A intakes lower than the recommended levels. This fact, together with the wide ranges of intakes (129 - 2831 RE for the girls and 113-2085 RE for the boys) suggested that large proportions of the children had intakes below the recommended levels.

The communities were divided into four groups according to the following criteria: Code 1 communities had zero or one store, air access for food, a health centre or visiting nurse service, and no media service; Code 2 communities had one or more stores, road access, a health centre, and limited media service; Code 3 communities had one or more stores, road access to food supplies, a health centre, and limited media service; and Code 4 communities had a good variety in number and type of stores, excellent access to food supplies, and good health and media services.

In the discussion of nutrient intakes among the different residence codes, data for all age and sex groups were considered together. Mean deviations from the recommended intakes were used for comparison. All residence codes had negative mean deviations from the recommended vitamin A intakes. Code 4 had the smallest mean deviation (-21 RE) or, in other words, the highest intakes relative to the recommendations. Code 3 had the largest mean deviation (-180 RE) or the lowest intakes relative to recommendations. Codes 1 and 2 had mean deviations of -102 and -59 RE, respectively. The pattern was similar for all five nutrients measured in that Code 4 generally had the highest intakes, Code 3 had the lowest intakes, and Codes 1 and 2 had intakes between Codes 3 and 4. Thus nutrient intakes appeared to vary among the resident codes, although not in a simple linear relationship with degree of isolation and access to services.

Four other studies which quantified vitamin A intakes among Canadian Indians presented their results in international units (Lee et al., 1971; Stepien, 1978; Dong and Feeney, 1968; and Johnston et al., 1977). They used the recommended vitamin A intakes from the 1964 Dietary Standard for Canada for comparison (Health and Welfare Canada, 1964). As mentioned previously, those recommendations if assumed to be comprised of retinol and carotene in equal proportions, would be lower than current recommendations expressed in retinol equivalents (Table 1).

In Anaham, a village in the interior of British Columbia, Lee and coworkers (1971) found that the mean intakes for children aged 6 to 13 years were 1.5 to 2 times the recommended intakes, but those for females and males aged 13 to 20 years were below the recommendations. In addition 33 to 72% of the individuals in each group had intakes below two thirds of the recommended level. In Ahousat, a coastal village, the mean intakes were between 1.5 and 3 times the recommended levels for all groups of children and teenagers. The proportions of individuals consuming less than two thirds of the recommendations were smaller than those in Anaham, however, 17 to 36% of teenagers did not meet that level. It was mentioned that significant amounts of vitamin A were provided by traditional foods from the sea, sources which were not available to Manitoba residents in the present study.

Stepien (1978) investigated dietary intakes among Indians on isolated and non-isolated reserves in British Columbia. An isolated reserve was defined as one having only one or two small general stores, a health station with monthly visits by Medical Services personnel, and being 50 or more miles from a centre with a population of at least 5000. An additional difference was noted between the two groups; all four of the isolated reserves were inland, whereas two of the three non-isolated reserves were on the coast.

On the isolated reserves the mean vitamin A intakes of the children and teenagers ranged from 1 to 2.5 times the recommended levels. Between 7 and 36% of the individuals had intakes less than two thirds of the recommendations. The mean intakes were higher on the non-isolated reserves and smaller proportions of individuals failed to consume two thirds of the recommendations. The author noted that a higher percentage of the vitamin A was provided by milk and milk products on non-isolated reserves, and fruit and vegetable intakes were lower on isolated reserves.

Low vitamin A intakes were found among Indian and non-Indian school aged children in Alert Bay, another village on the west coast of British Columbia (Dong and Feeney, 1968). The mean intakes were 629 and 916 IU, respectively. The investigators postulated that the major reason for the low intakes was the lack of green leafy and yellow vegetables in the diets. They also commented that butter or margarine was rarely used by either group of children, that the Indian children consumed limited amounts of milk products, and that the diet history failed to include tomato ketchup, a vitamin A source which was known through records of purchase to be frequently used by the native population.

Johnston and coworkers (1977) studied dietary intakes among Indian and Caucasian women in Nova Scotia. The median vitamin A intake for the Indian women was significantly less than that for the Caucasian women (3707 vs 4664, p=0.03), and although the median intake for the Indian women approximated the recommended intake, 49% of them consumed less than the recommended amount. This study did not include data for school aged children, however, the proportions of apparently deficient intakes were similar to those mentioned for children in other studies.

The three American studies shown in Table 2 reported their data in international units (ICNND, 1964a and 1964b; and Bass and Wakefield, 1974) and used the 1964 or 1968 United States vitamin A recommendations for comparison (Food and Nutrition Board, 1964 and 1968). Conversion of those recommendations, assuming equal contributions of retinol and carotene, would result in values similar to current recommended intakes expressed in retinol equivalents (Table 1).

The mean vitamin A intakes for children aged 10 to 15 years on both reserves in Montana ranged from 10 to 58% of the recommendations (ICNND, 1964a and 1964b). A follow-up study was carried out on the Blackfeet reserve in 1973 after the implementation of improved commodity supply, school breakfast, and nutrition education programs. Vitamin A intakes were not quantified. However, the results indicated that 36% of the families consumed milk and milk products once per day or less, and 41% consumed vitamin A-containing vegetables three times a month or less. The authors considered such consumption levels to be inadequate (MacNeill et al., 1981).

In a study from the Standing Rock reserve on the border between the Dakotas, the diets of women aged 19 to 75 years were assessed. The mean vitamin A intake was similar to the recommended level, however, 64% of the group had intakes less than three quarters of the recommendation (Bass and Wakefield, 1974).

Three Canadian studies estimated the per capita availability of vitamin A from food disappearance data (Moore et al., 1946; Vivian et al., 1948; and Gillis, 1980). In an older study from Nelson House, Manitoba, Moore and coworkers (1946) estimated the amount of vitamin A available from store-bought foods to be 238 IU per person per day, approximately 5% of the weighted recommended intake of 4590 IU.

Several years later Vivian and coworkers (1948) estimated the amount of vitamin A available from store-bought food, wild game, and garden produce in two James Bay communities.

The weighted recommendation for vitamin A intake which was used for comparison was 4300 IU. The estimates of vitamin A available in the communities were 0.5 and 1.7 times the recommendation.

Gillis (1980) studied the effects of a transport subsidy for perishables (fresh and frozen milk, meat, poultry, fish, fruit, vegetable, cereal, and fat products) on nutrient availability in four northern Saskatchewan communities accessible only by air. Manitoba had no northern transport subsidy for perishables at the time of the present study. In the four communities, the estimated daily per capita availabilities of vitamin A from perishables when no subsidy was in effect were 0.6, 1.2, 1.8, and 2.0 times the recommended intake of 750 RE.

Limitations in these last three Canadian studies must be acknowledged. Not all food sources were included in the analyses, thus the reported amounts of available vitamin A were underestimates. The study by Vivian and coworkers (1948) was the most complete, excluding only small amounts of wild berries. Moore and coworkers (1946) did not include sources other than store-bought foods. Other possible sources of vitamin A were wild foods and garden produce. The study by Gillis (1980) was based on the amount of nutrients available from store-bought perishables. Vitamin A may also have been provided by some canned vegetables, soups, and milk, powdered milk, and wild foods.

Variations in individual intakes and seasonal availabilities (the figures presented for all three studies were year long averages) would increase concern about the vitamin A status of the populations. Not all individuals would have had the same opportunity to consume the estimated average amount of available vitamin A. These factors would be exacerbated by the fact that vitamin A is found in substantial amounts in few foods.

The authors of most of the studies reviewed to this point indicated that the availabilities or intakes of dairy products, vegetables (other than potatoes), and fruits were low. These food groups contain foods that are good sources of vitamin A, thus their low prevalence in the diets of native persons is of concern with respect to vitamin A status.

Several food frequency studies found similar dietary patterns (O'Neill, 1976; Rempel, 1980; Kroeker and Knott, 1980; and Pass, 1976). O'Neill (1976) presented data from children in 18 schools in the Frontier School Division in northern Manitoba. Twenty-four hour recall data were gathered during the summer of 1974 before a school milk supplement and nutrition education program was implemented for nursery to grade four students, and during the winter of 1975, approximately six months after the start of the program. The results were presented separately for three groups of children: Group 1 consisted of 103 children involved only in the summer phase prior to the program implementation; Group 2 consisted of 81 children involved only in the winter phase subsequent to the program implementation; and Group 3 consisted of 39 children involved in both phases of the study.

In the summer when no school milk supplement was available the mean daily intake of dairy products for Group 1 children was 2.0 servings, and for Group 3 children it was 2.3 servings. The proportions of children who consumed the recommended amount of 2.5 servings were 36 and 44%, respectively. In the winter when a supplement equivalent to eight ounces of milk was offered to each child, the mean daily intake for Group 2 children was 2.4 servings, and that for Group 3 children was 2.6 servings, with 53 and 62%, respectively, consuming the recommended number of servings. For the Group 3 children, the mean intake of milk products was significantly greater when the school supplement was offered than when it was not available, although the difference between the mean intakes was less than half the amount of the supplement offered to each child.

The intakes of fruits and vegetables (excluding potatoes) were similar for all groups of children. No supplements were offered and time of year did not affect the intakes. The mean daily intakes for fruits ranged from 1.2 to 1.3 servings, with between 21 and 26% of the children consuming the recommended intakes of two servings per day. Powdered fruit drinks were included in the calculations of the intakes, although they are poor substitutes for fruit juices since they are comprised mainly of sugar with some added vitamin C. For vegetables the mean daily intakes were approximately one half of a serving for all groups and few children (0 to 2.6%) met the recommended intakes of two servings per day.

Subsequent surveys were done in the Frontier School division as part of an ongoing evaluation of the nutrition program. Rempel (1980) reported the results of one study carried out in the spring of 1978 and another done in the spring of 1980. In each case students from 15 schools were involved. Twenty-four hour recalls were obtained from 278 students in 1978 and 244 students in 1980.

In 1978 the percentages of children with desirable intakes of dairy products were similar to or lower than those found by O'Neill (1976) despite the fact that the recommended intake used for comparison was 2 servings per day rather than

2.5. When the school supplement was not included in the calculations, between 7 and 40% of the students in most schools had desirable intakes. The proportions of children with desirable scores when the supplement was included ranged from 30 to 65% in most schools.

In 1980 the percentages of children with desirable intakes of dairy products were higher than in 1978, however, there remained room for improvement. When the school supplement was not included, 30 to 80% of the children in most schools consumed two or more servings per day of dairy products. With the supplement included, between 70 and 95% of the children in most schools had desirable intakes.

The percentages of children in the 15 schools who consumed the desired amounts of fruits and vegetables other than potatoes (two servings daily of each) were higher than those reported by O'Neill (1976), however, they were lower than optimal levels. A school fruit supplement was offered on the day of the recalled intake in four schools in 1978 and three in 1980. When the supplement was excluded from the calculations the proportions of children in most schools who consumed two or more servings of fruit per day ranged from 61 to 80% in 1978 and 15 to 65% in 1980. For the seven cases where the supplement was offered, 40 to 95% of the children had desirable levels of fruit intake. Intakes of fruit drinks were included in the analyses, thus the intakes of fruits providing a variety of nutrients (not only vitamin C) were lower than the levels reported. No school vegetable supplements were offered at the time of either study. The proportions of children consuming two servings or more per day ranged from 5 to 71% in 1978 and 0 to 39% in 1980.

Pass (1976) conducted a study in two Indian communities in northwestern Quebec. Twenty-four hour recall data were collected for family members from 18 heads of households and the data were compared to the recommendations in Canada's Food Guide. The average daily serving size of dairy products per family member was 0.32 servings, and 67% of the individuals did not meet their recommended daily intake (1.5 to 4.0 servings depending on age). For dark green and yellow vegetables, the recommended intake was one serving daily. The average daily serving size per family member was 0.07 servings, and 89% of the individuals did not consume the recommended amount. The average daily serving size of citrus fruit and tomatoes was 0.91 servings, approximately the recommended intake of one serving per day. However, 33% of the children and 50% of the adults did not consume the recommended amount. The recommended intake for other fruits and vegetables was two servings per day. The average daily serving size per family member was 0.93 servings with 72% of the individuals not meeting the recommended level. The author noted that the limiting factors in the consumption of dairy products, fruits, and vegetables were the lack of familiarity, poor market supply (both in quantity and variety), and the lack of storage facilities.

A study performed by Kroeker and Knott (1980) in St. Therese Point, Manitoba gathered data from representatives of 19 households. They were asked to indicate whether a number of individual foods were consumed often (that being five or more times a week), sometimes, or never. This type of data is hard to evaluate due to the wide range of frequency of use that the "often" and "sometimes" categories may include. However, the food groups least represented in the diets were dairy products, fruits, and vegetables other than potatoes.

Descriptions of food consumption patterns made by health professionals who have worked with native peoples also suggested diets low in dairy products, fruits, and vegetables (Berkes and Farkas, 1978; Bossenmaier, 1975; Lang, 1960; Lederman, 1975; Norquay, 1956; Smith, 1975; and Woolcott, 1975). For example, Smith (1975), a consultant for maternal and child health for the Medical Services Branch of Health and Welfare Canada, related the following:

> **Vegetables and fruits are very little used...native vegetables are hardly ever used. Canned vegetables are not often available, and the variety for selection is**

> very restricted in the stores of isolated places...Vegetables are usually considered too expensive to buy...

> What the school child gets at home will be a small amount of milk, some meat, lots of bread, sweet tea or pop, and perhaps sometimes canned sweet fruit or a treat. The school feeding programs...seem to revolve around milk...and the vitaminized biscuit...developed by the Department of National Health and Welfare specifically for the native child in Canada.

Bossenmaier (1975) described the food purchasing patterns of native people in the Churchill area as follows:

> The grocery items that are considered most essential are meat, tea, sugar, canned (evaporated) milk, lard, flour, baking powder, salt and salt pork...Beyond these basics...other rather common foods are boxed macaroni and cheese dinners, canned stews, spaghetti, baked beans, eggs, packaged sandwich meat, peanut butter and cookies. Fresh vegetables, fruit and dairy products are least common, although a lot of potatoes are consumed.

She also explained that many of the native people supplemented their diets with wild game, but few wild plants were used for food.

A disincentive in the purchase of dairy products and vegetables is their high price. Manitoba price statistics showed that the overall food prices in northern isolated communities (Norway House, Split Lake, Island Lake, and Leaf Rapids) were 13 to 40% higher than Winnipeg prices in June, 1981 (Manitoba Bureau of Statistics, 1981) and 25 to 60% higher in December, 1981 (Manitoba Bureau of Statistics, 1982). The prices for dairy products in the northern communities varied from 9 to 73% greater than Winnipeg prices, usually being similar to or lower than the overall food price indices. For fruit and vegetables the prices ranged from 4 to 113% greater than Winnipeg prices, and were generally among those food groups with the highest price indices in each community.

Besides dairy products, vegetables, and fruits, other potential sources of vitamin A are eggs, organ meats and wild foods. A number of studies carried out in native communities reported that eggs were commonly consumed or made major contributions to nutrient intakes (Ellestad-Sayed et al., 1981; Gillis, 1976; Johnston et al., 1977; Kroeker and Knott, 1980; and Stepien, 1978). The consumption of organ meats was not considered separately from the consumption of the meats and alternates food group in any study, thus their level of use is unknown.

Major potential wild sources of vitamin A include the organ meats of animals and fish, the flesh of moose and some types of fish, and some forms of wild vegetation (Health Services and Promotion Branch, 1979; and Berkes and Farkas, 1978). However, it has been reported that the use of wild plants has been limited (Berkes and Farkas, 1978; Bossenmaier, 1975; and Smith, 1975).

Many investigators reported the use of wild fish and game by native peoples, however, the overall level of use as well as the seasons of use varied among the communities studied (Bossenmaier, 1975; Bureau of Nutritional Sciences, 1977; Gillis, 1976; Lederman, 1975; Lee et al., 1971; Pass, 1976; Social and Economic Impact Study Team, 1975; Stepien, 1978; and Woolcott, 1975). In addition there has been a trend away from the use of wild foods by native peoples due to several reasons: people have become less mobile forming settlements around schools and jobs, children who were sent to residential schools have had less chance to learn bush skills and acquire tastes for the foods, some wild food supplies have declined in numbers, and others have been polluted rendering them unfit for consumption (Berkes and Farkas, 1978; Bossenmaier, 1975; Goldthorpe, 1975; Pass, 1976; and Smith, 1975).

Biochemical Indicators of Vitamin A Status

Table 3 presents the results of studies which analyzed serum vitamin A levels among native peoples from several regions across Canada, plus two reserves in Montana where dietary patterns were found to be similar to those among Manitoba Indians. Serum vitamin A is the only biochemical indicator of vitamin A status which is practical for use in nutritional surveys; it is not feasible to routinely take liver biopsies, and serum carotene levels only reflect recent intakes of the provitamin, not overall vitamin A status (Sauberlich et al., 1974a). Nevertheless, there are several factors which affect serum vitamin A levels which must be considered in the interpretation of results.

Vitamin A-rich meals have not been found to raise serum vitamin A concentrations above fasting levels up to six hours following the meals (Kimble, 1939; Mejia and Arroyave, 1983; and Mejia et al., 1984). However, serum levels have been reported to be elevated after the injestion of a single dose of a vitamin A concentrate (Kagan, 1953; Kimble, 1939; McCoord et al., 1948; Molla et al., 1983; and Popper et al., 1948), and Owen and coworkers (1974) found that children who regularly took a vitamin A supplement had higher serum levels than those who did not. Thus the consumption of a supplement

Table 3. Results of studies which measured serum vitamin A levels (μg/100 ml).

Researchers	Sample Description: Location	Age	Sex	n	Mean ($\bar{x}$) or Median (md) Level	Percent in Risk Categories: High	Moderate	Risk Category Classifications	Comments
Bur. Nutr. Sci., 1975a	Nutrition Canada Indian Popn. (across Canada)	5-9 yr	M&F	215	md = 35	0.0%	26.1%	-High risk < 10 -Moderate risk 10-30	
		10-19 yr	F	245	md = 41	0.0%	13.7%		
		10-19 yr	M	192	md = 41	0.0%	13.3%		
	Nutrition Canada National Popn. (across Canada)	5-9 yr	M&F	1192	md = 39	0.0%	14.3%		
		10-19 yr	F	1459	md = 44	0.1%	5.6%		
		10-19 yr	M	1372	md = 48	0.0%	4.5%		
Desai and Lee, 1971	Anaham, B.C.	< 13 yr	M&F	72	$\bar{x}$ = 38	5.6%	2%	-High risk < 10 -Moderate risk 10-19.4	-% values without decimals estimated from bar graphs
	Ahousat, B.C.	< 13 yr	M&F	80	$\bar{x}$ = 46	1.2%	2%		
Desai and Lee, 1974	Upper Liard, Y.T.	< 13 yr	M&F	71	$\bar{x}$ = 36	5%	10%	-As above	-% values estimated from bar graphs
	Ross River, Y.T.	< 13 yr	M&F	44	$\bar{x}$ = 37	5%	3%		
ICNND, 1964a	Fort Belknap Reservation (N. Montana)	5-14 yr	F	18	$\bar{x}$ = 13	27.8%	61.1%	-High risk < 10 -Moderate risk 10-19	
		5-14 yr	M	32	$\bar{x}$ = 11	40.6%	56.2%		
ICNND, 1964b	Blackfeet Reservation (N.W. Montana)	5-14 yr	F	30	$\bar{x}$ = 28	0.0%	36.7%	-As above	
		5-14 yr	M	38	$\bar{x}$ = 24	7.9%	31.6%		
MacNeill et al., 1981	Blackfeet Reservation (N.W. Montana)	6-17 yr	M&F	136	$\bar{x}$ = 42	0.0%	0.0%	-As above	

Table 3. (continued)

Researchers	Sample Description Location	Age	Sex	n	Mean ($\bar{x}$) or Median (md) Level	Percent in Risk Categories High	Moderate	Risk Category Classifications	Comments
Best and Gerrard, 1959	Pine House, Sask.	6-16 yr	F	27	$\bar{x}$ = 14 (9-25)[a]	----	----	----	
		6-16 yr	M	15	$\bar{x}$ = 14 (6-32)	----	----		
	Pelican Narrows, Sask.	2-5 yr	F	8	$\bar{x}$ = 16 (10-38)	----	----		
		2-5 yr	M	6	$\bar{x}$ = 14 (8-22)	----	----		
	Regina, Sask. (controls)	7-18 yr	M&F	13	$\bar{x}$ = 28	----	----		
Best et al., 1961	Pine House, Sask.	---	F	---	$\bar{x}$ = 24 (6-67)[a]	----	----	----	
		---	M	---	$\bar{x}$ = 35 (13-61)	----	----		
	Pelican Narrows, Sask.	---	F	---	$\bar{x}$ = 26 (13-61)	----	----		
		---	M	---	$\bar{x}$ = 31 (10-76)	----	----		
Hoffer et al., 1981	3 James Bay Communities	> 30 yr	M&F	478	md = 41	0.0%	10.2%	-High risk < 10 -Moderate risk 10-30	-md estimated from percentile graphs

[a]Range

containing a concentrated form of vitamin A is a possible confounding variable when non-fasting blood samples are used for the analyses of serum vitamin A levels.

The authors of two of the studies presented in Table 3 indicated that non-fasting blood samples were used (Bureau of Nutritional Sciences, 1975a; and Hoffer et al., 1981). There was no indication of whether the blood samples were fasting or non-fasting in the other studies cited. In the older studies on the Fort Belknap and Blackfeet reservations, the authors noted that one and four children, respectively, consumed vitamin supplements (ICNND 1964a and 1964b). Desai and Lee (1971) and Best and coworkers (1961) indicated that vitamin biscuits were distributed in the schools. However, the level of vitamin supplement usage was not reported in any of the other studies presented in Table 3.

Another factor to consider in the interpretation of serum vitamin A levels is that they do not necessarily reflect recent intakes of the vitamin. When intakes are in excess of daily needs the surplus is stored in the liver, and in the absence of adequate dietary sources of vitamin A, serum concentrations are maintained at physiologically adequate levels through the mobilization of liver stores. When liver stores are nearly depleted, serum vitamin A levels fall rapidly (Bureau of Nutritional Sciences, 1975a; Lui and

Roels, 1980; and Sauberlich et al., 1974a).

The homeostatic nature of serum vitamin A regulation has led to some uncertainty about the interpretation of levels between 20 and 30 μg/100 ml of serum (Sauberlich et al., 1974a). Some of the studies cited in Table 3 used 20 μg/100 ml and others used 30 μg/100 ml as the level above which there was considered to be a low risk and below which there was considered to be a moderate risk of vitamin A deficiency. All studies considered 10 μg/100 ml to be the level below which the risk of vitamin A deficiency was high.

Incidences of abnormal dark adaptation attributable to vitamin A deficiency have been reported at serum levels greater than 20 μg/100 ml. Sauberlich and coworkers (1974b) conducted a study in which eight adult male volunteers were fed vitamin A deficient diets. The plasma vitamin A level at which dark adaptation impairment occurred was between 20 and 30 μg/100 ml for three of the subjects and between 30 and 35 μg/100 ml for one subject. Carney and Russel (1980) studied the relationship between dark adaptation test results and serum vitamin A levels in chronically ill adults without zinc deficiency or eye disease. They found that 9 of 12 patients with serum levels between 20 and 29 μg/100 ml and 6 of 18 patients with serum levels between 30 and 39 μg/100 ml had abnormal dark adaptation. Among 28 patients with serum vitamin A levels greater than or equal to 40 μg/100 ml, one was found with abnormal dark adaptation. However, it did not reverse with vitamin A therapy and the authors suggested that for patients with serum vitamin A levels of 40 μg/100 ml or greater, causes other than vitamin A deficiency should be looked for. These observations would support the use of 30 μg/100 ml, or possibly higher, as the serum level below which there is considered to be a risk of vitamin A deficiency.

Several studies cited in Table 3 reported both dietary intakes and serum levels of vitamin A (Bureau of Nutritional Sciences, 1975a; Desai and Lee, 1971; ICNND, 1964a and 1964b; and MacNeill et al., 1981). Comparisons of the biochemical indicators of vitamin A status with dietary indicators showed consistent findings for most groups studied.

Nutrition Canada was the only study to include biochemical data for Manitoba Indians (Bureau of Nutritional Sciences, 1975a). The median serum vitamin A levels for the Indian children on reserves across Canada were within the category considered to be associated with a low risk of vitamin A deficiency (>30 μg/100 ml). However, they were lower than those for the same age and sex groups in the national sample. The children in the national sample were selected from all population groups in the 10 provinces, excluding Indians on reserves and residents of institutions or military camps. No Indian children had serum levels associated with a high risk of vitamin A deficiency (<10 μg/100 ml). However, between 13 and 26% were found to be in the moderate risk category (10 to 30 μg/100 ml), two to three times the proportions found for children in the national sample. The biochemical data showed similar trends to the dietary data (Table 2) which suggested that Indian children had a lower vitamin A status than did the children in the national sample. Concern was expressed in the report that the vitamin A liver stores of Indians may have been low.

Desai and Lee (1971 and 1974) measured the serum vitamin A levels of children in two British Columbia communities, Anaham and Ahousat, as well as two communities in the Yukon Territories, Upper Liard and Ross River. The mean serum levels for children under 13 years of age were similar to the median values reported for Indian children in the Nutrition Canada survey. The proportions of children considered to be at moderate risk of vitamin A deficiency were smaller than those reported for the Nutrition Canada Indian children. However, Desai and Lee used 19.4 μg/100 ml, rather than 30 μg/100 ml, as the upper limit of the moderate risk category. In Ahousat 1.2% of the children up to 13 years of age were considered to be at high risk of vitamin A deficiency; in Anaham, Upper Liard, and Ross River approximately 5% of the children had serum vitamin A levels below 10 μg/100 ml. An international expert committee suggested that serum vitamin A levels below 10 $\mu g/100$ ml in more than 5% of a population would indicate a significant prevalence of vitamin A deficiency (WHO et al., 1982).

Dietary studies in Anaham and Ahousat (Lee et al., 1971) suggested similar results to the biochemical data. Many children under 13 years of age at Anaham had vitamin A intakes below the recommended levels. At Ahousat, where fewer children had serum levels associated with a high risk of vitamin A deficiency, smaller proportions of children consumed less than the recommended levels (Table 2).

Two older Montana studies found lower serum vitamin A levels which were in support of the dietary findings (ICNND, 1964a and 1964b). The mean serum vitamin A levels for the 5 to 14 year old Fort Belknap children were 13 and 11 $\mu g/100$ ml for girls and boys respectively. Twenty-eight percent of the girls and 41% of the boys had serum vitamin A concentrations less than 10 $\mu g/100$ ml. On the Blackfeet reservation the mean levels were higher (28 and 24 $\mu g/100$ ml), and although no girls had levels below 10 $\mu g/100$ ml, 8% of the boys were at high risk of vitamin A deficiency. As well, 37% of the girls and 32% of the boys had serum levels between 10 and 19 $\mu g/100$ ml.

The investigators of the follow up study on the Blackfeet reserve in 1973 suggested that there was no longer a problem with vitamin A status (MacNeill et al., 1981). Although many families were considered to have inadequate intakes of dairy products and vitamin A-containing vegetables, the mean serum vitamin A concentration for the 6 to 17 year old children was 42.3 μg/100 ml and no children were considered to be at risk of vitamin A deficiency. However, the investigators used 19 μg/100 ml as the upper limit of the category considered to be associated with a moderate risk of vitamin A deficiency.

Other biochemical studies had no accompanying dietary data (Best and Gerrard, 1959; Best et al., 1961; and Hoffer et al., 1981). Two older studies were carried out in Pine House and Pelican Rapids, Saskatchewan (Best and Gerrard, 1959; and Best et al., 1961). Measurements were made in the two communities before and one and a half years after a school lunch program was implemented in Pine House. The initial serum vitamin A levels in both communities were low with means between 14 and 16 μg/100 ml. The range of intakes suggested that most children were at risk of vitamin A deficiency. In the follow-up study the serum vitamin A levels were higher in both communities, with the means falling between 24 and 35 μg/100 ml. However, higher extremes were recorded for the ranges of values for each group of children. This suggested that some children were still at risk of vitamin A deficiency.

A large study was carried out more recently in three isolated Cree communities in the James Bay area (Hoffer et al., 1981). It involved only adults aged 30 years and over, however, trends were similar to those reported by others for children. The investigators compared their data with results for adults 20 years and over in the Nutrition Canada survey (Bureau of Nutritional Sciences, 1975a). The results indicated that the James Bay group had serum vitamin A levels lower than the Nutrition Canada Indian sample, who in turn had levels lower than the Nutrition Canada national sample. No individuals were considered to be at high risk of vitamin A deficiency. However, 10.2% of the James Bay population were in the moderate risk category (10 to 30 μg/100 ml) compared to 4.1% of the Indian population and 1.6% of the national population in the Nutrition Canada survey. For the Nutrition Canada adult Indian population living in areas remote from urban centres there were 7.9% considered to be at moderate risk of vitamin A deficiency, a value closer to that found for the James Bay sample.

Clinical Indicators of Vitamin A Status

The functions of vitamin A are numerous. An early clinical symptom of vitamin A deficiency is impaired dark adaptation ability which results from a disruption in the production of retinal-containing photosensitive pigments in the eyes. Vitamin A also has a function in maintaining healthy epithelial cell structure throughout the body. During vitamin A deficiency, xerosis (drying) of epithelial tissues occurs and they become susceptible to infections. Tissues affected include the skin, the linings of the respiratory and intestinal tracts, and the surface of the eye. Changes in the conjunctiva and cornea can progress to blindness if left untreated. Vitamin A deficiency has also been found to result in abnormal bone growth, nerve lesions, and increased cerebrospinal fluid pressure (Bureau of Nutritional Sciences, 1975a; and Lui and Roels, 1980).

Severe vitamin A deficiency has rarely been reported in North America (Bureau of Nutritional Sciences, 1975a). Several studies reported incidences of follicular hyperkeratosis of the skin and thickened discoloured conjunctivae among Canadian Indians (Birkbeck et al., 1971; Bureau of Nutritional Sciences, 1975a; Moore et al., 1946; Pett, 1950; Sinclair, 1953; and Vivian et al., 1948). However, the findings did not always agree with other measured indices of vitamin A status. It has been suggested that follicular hyperkeratosis may also be caused by poor hygiene, environmental exposure or fungus infections, and that the prevalence of the most common conjunctival abnormalities increases with age and may be related to racial origin or environmental exposure (Bureau of Nutritional Sciences, 1975a). In the light of these observations, it seems that the reported abnormalities of skin and eyes cannot be attributed solely to poor vitamin A status.

No study measured dark adaptation ability among native Canadians. The cumbersome nature of the classical dark adaptation method renders it unsuitable for survey purposes. Thornton (1977) proposed an easily transportable rapid dark adaptation test. The test is based on the time it takes for the Purkinje shift to occur. This is the phenomenon whereby the retina sensitivity to light wavelength changes as it dark adapts. Under daylight conditions the retina is more sensitive to light from the red end of the spectrum, but as it dark adapts it becomes more sensitive to light of shorter wavelengths. Under conditions of low light intensity, where colour vision does not operate, the Purkinje shift is perceived when blue objects appear to be a brighter grey than red objects.

The rapid dark adaptation test was evaluated by Vinton and Russell (1981) who found that the results correlated well with classical dark adaptation parameters and serum vitamin A levels in adults. Solomons and coworkers (1982) found that the test was applicable for use among children as young as four or five years of age from two different cultural backgrounds.

Conclusions

The literature cited indicated that the vitamin A status of school children of native ancestry in northern Manitoba communities may be suboptimal. Although mean or median intakes of vitamin A for groups of Indians have been recorded at levels similar to or greater than recommended levels, studies often identified substantial percentages of individuals who did not meet the recommendations. The consumption of dairy products, vegetables, and fruits was reported to be low among native peoples, an observation which supports the findings of low vitamin A intakes since these food groups contain foods which are good sources of vitamin A.

Serum vitamin A levels among Indians were lower than those found for the general Canadian population, and there were greater proportions of Indians with serum vitamin A levels in categories associated with a risk of vitamin A deficiency. Among several groups of Indian children there were 5% or more of the individuals with serum vitamin A levels less than 10 µg/100 ml, a finding considered to be indicative of a significant prevalence of vitamin A deficiency (WHO et al., 1982).

Several factors may influence the vitamin A status among native children. There was some indication that vitamin A intakes (Gillis, 1976; and Stepien, 1978) and serum levels (Hoffer et al., 1981) varied according to the degree of isolation, access to food, and levels of media and medical service in the communities, although not necessarily in a simple linear manner. In addition, in communities where a school milk supplement was distributed to improve the nutritional status of the children, mean intakes of dairy products were found to be higher than basal levels (O'Neill, 1976), and greater proportions of the student populations had dairy product intakes equal to or greater than recommended levels (O'Neill, 1976; and Rempel, 1980). Because milk products are good sources of vitamin A, an increase in their consumption would be expected to be associated with an increase in vitamin A intakes.

The development of a nutritional deficiency is sequential in nature, beginning with inadequate intakes which lead to biochemical disturbances and finally clinical signs of deficiency (Bureau of Nutritional Sciences, 1975a). Therefore the assessment of the vitamin A status of a population group should involve a combination of dietary, biochemical, and clinical indicators. The use of several indicators is also necessary to avoid misleading results due to the inherent variability in the measurements recorded.

RESEARCH DESIGN

The literature indicated that the vitamin A status of school children of native ancestry in northern Manitoba communities may be suboptimal. Vitamin A has numerous functions. Impaired dark adaptation ability is an early symptom of vitamin A deficiency. In addition, xerosis occurs to epithelial tissues and they become susceptible to infections. In the case of the eyes, vitamin A deficiency can lead to blindness if left untreated. Abnormalities in bone growth and the central nervous system have also been associated with vitamin A deficiency (Bureau of Nutritional Sciences, 1975a; and Lui and Roels, 1980).

Several factors may influence the vitamin A status among native children. There was some indication that vitamin A intakes (Gillis, 1976; and Stepien, 1978) and serum levels (Hoffer et al., 1981) varied according to the degree of isolation, access to food, and levels of media and medical service in the communities. In addition, in communities where a school milk supplement was distributed to the children, mean intakes of dairy products were found to be higher than basal levels (O'Neill, 1976). Increased dairy product consumption would be expected to result in increased vitamin A intakes.

The objectives of the present study were as follows:

1. to determine if indicators of the vitamin A status of school children differed among five northern Manitoba communities; and

2. to determine if indicators of the vitamin A status of school children differed between children who received a school food supplement and those who did not.

Fourteen related hypotheses which were tested are listed in Table 4. Community and school food supplement were the two independent variables used. The five communities chosen varied with respect to degree of isolation, access to food, and levels of medical and media services. In each community, both children who regularly received a school food supplement and those who did not were included. Brochet was an exception in that all children in the school received the supplement, thus its data were used for comparison when testing the hypotheses involving the supplement.

A total of seven dietary, biochemical, and clinical indicators of vitamin A status were used as dependent variables. All three types of indicators were used in order to have a composite view of the vitamin A status; one type alone would not adequately represent the vitamin A status.

Table 4. Hypotheses tested.

A. Independent variable = community

1. Dependent variables = dietary indicators of vitamin A status

   a. The absolute vitamin A intake of school children differs significantly among five northern Manitoba communities.

   b. The vitamin A intake of school children expressed as a percentage of the Canadian recommendation differs significantly among five northern Manitoba communities.

   c. The vitamin A intake of school children expressed as a percentage of the weight recommendation differs significantly among five northern Manitoba communities.

   d. The vitamin A density of the diet of school children differs significantly among five northern Manitoba communities.

2. Dependent variable = biochemical indicator of vitamin A status

   a. The serum vitamin A level of school children differs significantly among five northern Manitoba communities.

3. Dependent variables = clinical indicators of vitamin A status

   a. The DAT time of school children differs significantly among five northern Manitoba communities.

   b. The bestDAT time of school children differs significantly among five northern Manitoba communities.

B. Independent variable = school food supplement

1. Dependent variables = dietary indicators of vitamin A status

   a. The absolute vitamin A intake of school children is significantly greater for children receiving the school food supplement than it is for those not receiving it.

   b. The vitamin A intake of school children expressed as a percentage of the Canadian recommendation is significantly greater for children receiving the school food supplement than it is for those not receiving it.

   c. The vitamin A intake of school children expressed as a percentage of the weight recommendation is significantly greater for children receiving the school food supplement than it is for those not receiving it.

   d. The vitamin A density of the diet of school children is significantly greater for children receiving the school food supplement than it is for those not receiving it.

2. Dependent variable = biochemical indicator of vitamin A status

   a. The serum vitamin A level of school children differs significantly between children receiving the school food supplement and those not receiving it.

3. Dependent variables = clinical indicators of vitamin A status

   a. The DAT time of school children differs significantly between children receiving the school food supplement and those not receiving it.

   b. The bestDAT time of school children differs significantly between children receiving the school food supplement and those not receiving it.

Four methods of expressing vitamin A intake were used as dietary indicators. They were absolute vitamin A intake expressed in retinol equivalents, two variables expressed as percentages of recommended intakes, and vitamin A density expressed in RE/100 kcal. The two variables incorporating recommended intakes were chosen to reduce any effect age may have had on vitamin A intake. The last variable was chosen to detect differences in the concentration of vitamin A activity in the diets of different groups.

Table 5. Recommended Vitamin A Intakes

Age	Sex	Canadian[a] Recommendations	Weight[b] Recommendations
7 - 9 yr	M & F	700 RE	adequate intake = wt of child in kg x 20 up to a maximum of 750 RE
10 - 12 yr	M & F	800 RE	
13 - 15 yr	F	800 RE	(Range for study = 350 to 750 RE)
13 - 15 yr	M	900 RE	

[a](Bureau of Nutritional Sciences, 1983)

[b](Bureau of Nutritional Sciences, 1975a)

Table 5 shows the two sets of recommended intakes which were used for percentage calculations. The Canadian recommendations are based in part on body weight, however, they increase stepwise, remaining constant over three year intervals (Bureau of Nutritional Sciences, 1983). The weight recommendations used for comparison were suggested by Nutrition Canada investigators (Bureau of Nutritional Sciences, 1975a). They are a more individualized set of recommendations since the body weight for each child determines his or her recommended intake. Thus the recommendation increases gradually with age as the child grows. It appears that the weight recommendations have a smaller safety factor added than do the Canadian recommendations. They result in values similar to those recommended by an international expert committee for use among population groups around the world (Joint FAO/WHO Expert Group, 1967).

A single biochemical indicator was used--the total serum vitamin A expressed in μg/100 ml of serum. Two clinical indicators were used as dependent variables. Dark adaptation test times were recorded in duplicate. The average of the two recorded test times (DAT) and the best time of the two (bestDAT) were used. Both were expressed in seconds.

Three possible confounding variables were recognized. A test was done to determine if there were any interviewer effects on the intake data. Dark adaptation test data were examined for any differences between those children who had eye glasses prescribed but did not wear them, and those who either needed no vision correction or wore their glasses. In addition, it was considered that taking a vitamin supplement which contained a concentrated form of vitamin A may affect the serum vitamin A level and dark adaptation test performance. Thus it was added into the statistical models used to test the hypotheses involving these dependent variables. Vitamin A from vitamin concentrates was not included in the dietary intake data.

Tests to study the relationships between pairs of dietary, biochemical, and clinical variables were done to help interpret the results of the tests of the hypotheses. General descriptive data were also used in the discussion of the results. These included a calculation of the number of "true deficients" based on dietary intakes, and the comparison of serum vitamin A levels and dark adaptation test scores to standards or results from previous studies. In addition, information was gathered on the source of dietary intakes (store, school, locally produced, etc.) and the proportions of vitamin A intakes provided from major food groups.

METHODOLOGY

Community Selection and Description

The study was carried out under the auspices of the Nutrition and Health Program of the Frontier School Division of Manitoba.[1] In May and June of 1981, the director of the Nutrition and Health Program and a representative from the University of Manitoba visited each of the five communities involved in the study. They met with school committee members, as well as band and village councillors to explain the proposed study. The community representatives in each village approved the study and methods. Prior approval for the study was also obtained from the University of Manitoba following an ethical review of the procedures under its guidelines for research with human subjects.

The locations and populations of the communities are shown in Figure 1. Brochet was the most northerly and isolated of all of the communities in the study. It was regularly accessible only by air, and there were no radios or

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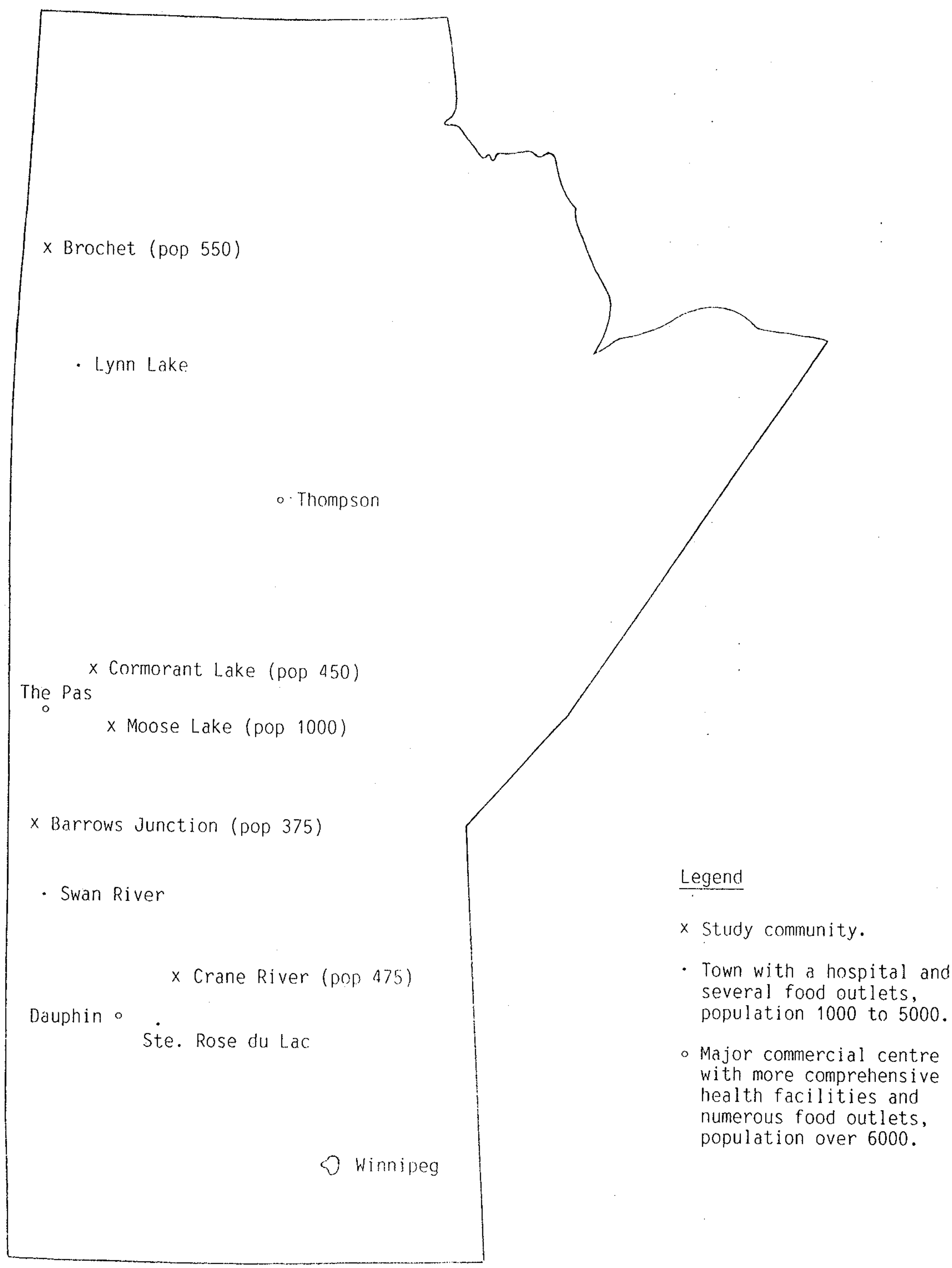
[1] The study was part of a larger investigation to evaluate the impact of the Nutrition and Health Program, which included information from adult women in the communities.

Figure 1. Locations and populations of communities involved in the present study. (Information from data collected in the field; Manitoba Department of Economic Development and Tourism, 1982; and Manitoba Department of Northern Affairs, 1981.)



television. There was one general store which received air shipments of food weekly. It had a nursing station staffed by three registered nurses, but it was 120 km by air from the nearest hospital at Lynn Lake. The distance to the major commercial centre of Thompson was 330 km.

All of the other communities were accessible by all-weather roads, and most homes had radios and televisions. Crane River and Barrows Junction had similar access to health and food facilities. Neither had a nursing station. They each had two small food outlets within the community. In Crane River there was one privately owned store and one band operated store, and in Barrows Junction there was one privately owned store and a small restaurant where lunch meals and snack foods could be purchased. They were both close to rural towns with hospitals and several food outlets. However, they were 120 and 170 km respectively from major commercial centres (Dauphin and The Pas) with more comprehensive health services and numerous food outlets.

Cormorant Lake and Moose Lake each had a nursing station with a fulltime Community Health Representative. Cormorant Lake had two small food outlets, one a general store and the other a restaurant where lunches and some canned and packaged goods could be purchased. Moose Lake had one large general store built the year before the study and one small general store. Both communities were close to The Pas (50 and 70 km respectively), a major commercial center providing health and food services.

School Food Supplement Description

A milk product was the basic component of the school supplement. Children in classes up to and including grade four were regularly offered 175 to 250 ml of milk, or 175 to 250 ml of juice and 20 g of cheese. They were sometimes offered 6 g of crackers or 25 g of peanuts in addition. Children in grade five or higher did not receive the supplement, except in Brochet where all children in the school were offered the supplement.

Sample Selection

In each community, 15 children from grade four and 15 from grade six were selected from class lists using a table of random numbers. In communities where there were insufficient numbers of students in grades four and six, students in grades three and five respectively were chosen to complete the samples. These combined samples will also be referred to as grade 4 and grade 6.

There were few refusals to participate. However, the parents or guardians of some students were not available in the communities. Replacements were chosen at random from the remaining subject pool. The lab technician collected blood from each child who agreed to the procedure and whose parent or guardian had given consent. To assure confidentiality, each child was assigned a unique number which was used throughout data analysis. (See Appendix 1 for the consent form and instructions for the interviewers on the verbal explanations to be given to the subjects.)

There were 143 children from which data of one or more types (dietary, biochemical or clinical) were used in the analyses. Seventy-two were in grade 4 (29 boys and 43 girls), and 71 were in grade 6 (33 boys and 38 girls). The mean age ± SEM for all grade 4 children was 10 yr 0 mo ± 2 mo; that for the grade 6 children was 12 yr 3 mo ± 2 mo. Most of the children involved in the study had some native ancestry; those who did not were children of teachers.

Data Collection

In September and October of 1981, a survey team consisting of two interviewers, a medical technician and the researcher travelled to each community. The interviewers and researcher were in each community for one week, while the medical technician remained for one day. In total four interviewers were involved in the study, of whom three were residents of northern Manitoba communities within the Frontier School Division, and the fourth had had previous contact with native people. It was felt that information would be more complete when gathered by persons familiar with the culture and living conditions of the survey participants.

Prior to the field work an eight day training course was held in Winnipeg for the interviewers. They were instructed in dietary interviewing and in making body weight measurements. During the training course the interviewing methods and recording forms were first pilot tested for their appropriateness for use among adults and children not of native ancestry available during the training sessions. This pilot phase was continued between the time of the training course and the field work, when the trainees used the forms to practice collecting data in their home communities in northern Manitoba. No changes in the forms were felt to be necessary after this pilot phase.

Five individuals were involved in the original training course, two of whom were available at the time of the survey work. The other two field interviewers were instructed by the same trainer in a two day course several days before they went into the field. The training courses were held in order to standardize the technique and to minimize the amount of interviewer variation. (See Appendix 2 for recording forms used and the explanation of the purpose and general instructions given to the interviewers.)

Two interviewers worked in Crane River, Moose Lake and Cormorant Lake, and the other two worked in Barrows Junction and Brochet. In Moose Lake, Cormorant Lake and Brochet, Nutrition Health Advisor trainees of the Frontier School Division were available to introduce the interviewers to the participants and aid in translation when necessary. In Cormorant Lake, Crane River and Barrows Junction, no translation was needed.

During the morning of the day on which the children were to be interviewed for dietary information, they were gathered together in a group of approximately 15. Each child was given a blank piece of paper to record the foods he or she had eaten in the past 24 hours. As a group, they were guided through a 24 hour recall, beginning at the time of the interview and ending at the same time the previous day. This group procedure was used to help the children understand what was expected of them and to help them feel more at ease.

Each child was interviewed individually at some time during the rest of the school day. Starting with what the child had recorded earlier, the interviewer recorded the types and amounts of foods consumed, how they were cooked, plus their sources. A selected number of food models were used to aid in the estimation of amounts. (See Appendix 3 for descriptions of models.) Children were also asked if they consumed a vitamin or mineral supplement. General information including the sex, age, and weight of each child was recorded.

The amounts of vitamin A and energy in the diets of the children, were determined using the 1978 Health and Welfare Canada nutrient database. The nutrient composition of bannock was modified on the basis of a recipe from a Nutrition and Health Advisor of the Frontier School Division, also a resident of a northern community. Entries were added for moose, vension, steakettes, and potatoes fried in butter. (See Appendix 4 for source information.)

Computer coding of all the diets was done by the researcher. Most solid foods were entered in grams for computer analysis. The percent edible portion and weight per volume or size of the foods were determined from the U.S. Handbook #456 (Adams, 1975). The weight per volume of bannock was calculated by weighing pieces of bannock made from the recipe given in Appendix 4. Commercial sliced bread was entered in units, i.e. number of slices. Liquids were entered in volume measures of either cups or millilitres.

For dishes common to all of the communities, such as homemade duck or rabbit soup, and a mixture of pasta and concentrated tomato soup, estimates of ingredients were obtained from the interviewers who were normally resident in northern Manitoba communities. Amounts of individual ingredients were used in the analysis.

Five millilitres of non-fasting venous blood were collected from each child. The blood was centrifuged after clotting, and the serum was frozen for shipment to Ottawa to the Bureau of Nutritional Sciences, Department of Health and Welfare Canada, where the vitamin A analyses were performed by the fluorescent method described by Thompson and coworkers (1973).

A modification of the rapid dark adaptation test developed by Thornton (1977), was used in this study. At each school, a light proof room was set up. A table covered with black felt was used as a non-reflective work surface for the test. Five white, six blue, and seven red plastic discs with a glossy finish were placed on this surface. Above the table was positioned a standard darkroom light fixture fitted with a 7.5 watt, 120 volt bulb and a neutral filter made from evenly exposed x-ray film. Some of this equipment, including the discs, was provided by Advanced Soft Optics.[2] The distance from the bottom of the fixture to the table surface was approximately 65 cm. It was adjusted for each new bulb so that the illuminance at the table surface remained constant at 2 x 10^{-3} footcandles. Calibration was made using a model 555 EG&G radiometer/photometer from Optikon Corporation.[3] The illuminance used would result in a target brightness of 2 x 10^{-3} footlamberts for a perfectly diffusing white target of 100% reflectance. This was the target brightness used by Thornton.

For light adaptation, a table lamp fitted with a 100 watt, 120 volt bulb was positioned over a white sheet of paper 61 by 45 cm, on which line drawings were placed to hold the attention of the children. (See Appendix 5 for the line drawings.) The brightness of the paper was from approximately 300 to 800 footlamberts as measured by the EG&G radiometer/photometer. The subject was to focus on this surface for 60 sec.

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[2] Advanced Soft Optics Inc., 113 23rd Ave. North, Nashville, TN, U.S.A., 37203.

[3] Optikon Corp. Ltd., 156 Duke St. West, Kitchener, Ont., N2H 3X1.

Before testing, each child was shown the mixed pile of coloured discs and told that after the lights were dimmed he or she should separate them as quickly as possible. The white ones were to be removed first with the child indicating when he or she was finished. The child was to continue, and give a final signal when the blue discs were separated from the red ones. The child was cautioned that in the dim light the red and blue colours would not be discernible, but that the blue discs would eventually appear to be a brighter grey than the red ones.

The child was then light adapted and a stopwatch begun when the 100 watt bulb was extinguished. The tester replaced any discs that the child removed incorrectly from the main pile. The time taken for the child to separate out all of the blue discs correctly was recorded to the nearest second. (See Appendix 6 for the recording form.)

A modification of this procedure was used in Crane River. Each child was told the number of discs of each colour and asked to separate them as above. At no time did the tester touch the discs. This procedure caused some children to count the discs, and it may also have been difficult for the children to see red discs which had been mistakenly separated into the blue pile. However, the variation was assumed to have negligible influence on the results.

Each child performed three consecutive trials. During the first trial the child became familiar with the task and no completion time was recorded. At the end of this trial and before the bright light source was switched on again, the tester discussed the appearance of the discs with the child. The times of the two subsequent trials were recorded for use in analysis. Both the average of these two times (DAT) and the best time of the two (bestDAT) were used since a paired t-test showed that the second recorded trial took significantly less time to complete than the first recorded trial ($p<0.02$).

Data Analysis

The dietary data for several children were excluded from the analyses of the hypotheses. The criteria for exclusion were as follows: 1) the record of the 24-hour recall was considered to be incomplete or unfeasible; and 2) the vitamin A intake was greater than 10 standard deviations from the mean intake for all children, and would therefore bias the results of the statistical tests. Nine records were excluded based on the first criterion. When foods which the child had recorded during the group procedure were not mentioned on the 24-hour recall form, with the result being that entire meals were missed, the record was excluded. In other cases, the amounts of foods recorded were too large to be physiologically possible for a child to consume. Based on the second criterion, one record was excluded. The vitamin A intake of one child was greater than 10 standard deviations from the mean intake for all children due to the consumption of beef liver. Because the main objectives of the study were to measure the community and school food supplement effects on the intake variables, the record was excluded since it would have biased the results of the tests of the hypotheses.

Summaries of the data groupings used to test the hypotheses and to test for the confounding variable effects are shown in Tables 6 and 7. The three confounding variables were either examined before or concurrent with the analyses of the hypotheses. To test for interviewer effects on the dietary intakes, one-way analysis of variance (ANOVA) tests for the ten community by grade groupings were done for both the total vitamin A and energy intakes before any hypothesis testing was performed (Table 6). Histograms of the residuals from these ANOVAs were plotted for each interviewer and compared visually for any differences.

The effect of consuming a vitamin A concentrate on serum levels or dark adaptation test scores was controlled for by entering it directly into the ANOVA procedures used to test

Table 6. Summary of data groupings used to test the hypotheses and to test for the confounding variable effects when the dependent variables were the dietary indicators.

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	a	a	b	b	a
Grade 6	c	c	c	c	a

Independent variable = community (hypotheses A.1.a to A.1.d)

--One-way ANOVAs and contrasts used data from all ten community by grade groupings (——).
(Note: Vitamin A and energy contributions from the school supplement were not included in the intake variables in order that all data were comparable.)

Independent variable = school supplement (hypotheses B.1.a to B.1.d)

--One-way ANOVAs and contrasts used data from the eight community by grade groupings excluding those from Brochet (- -).
--T-tests (grade 4 vs grade 6) used Brochet data for comparison (= =).

Confounding variable = interviewer

--One way ANOVAs to provide residuals used data from all ten community by grade groupings (——).

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[a] Children who received their regular school supplement on the day of the interview.

[b] Children who did not receive their regular school supplement on the day of the interview.

[c] Children who were not regularly offered the school supplement.

Table 7. Summary of data groupings used to test the hypotheses and to test for the confounding variable effects when the dependent variables were the biochemical or clinical indicators.

		Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	No vitamin Concentrate	a	a	a	a	a
	Vitamin Concentrate	a	a	a	a	a
Grade 6	No Vitamin Concentrate	b	b	b	b	a
	Vitamin Concentrate	b	b	b	b	a

Independent variables = community and school supplement (hypotheses pairs A.2.a/B.2.a, A.3.a/B.3.a, and A.3.b/B.3.b)

--Three-way ANOVA (community x school supplement[c] x vitamin A concentrate) used data from all groupings excluding those from Brochet (- -).

--Two-way ANOVA (community x vitamin A concentrate) used all grade 4 data to test for community differences with Brochet included (——).

--Two-way ANOVA (grade x vitamin A concentrate) used Brochet data for comparison with tests for school supplement effects (= =).

Confounding variable = vitamin A concentrate

--Included in all three ANOVAs mentioned above.

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[a]Children who regularly received the school supplement.

[b]Children who were not regularly offered the school supplement.

[c]Grade was a surrogate grouping variable for school supplement in this case.

for community and school supplement effects (Table 7). This procedure will be described in the description of the testing of the hypotheses.

Due to small sample sizes, the effect of failure to wear prescribed eye glasses could not be entered into the ANOVA models involving the dark adaptation test variables. Thus the mean DAT and bestDAT times for those children who did not wear their prescribed glasses were compared with those of the children who either needed no vision correction or wore their glasses.

For hypotheses A.1.a to A.1.d, tests for community differences in the dietary intake variables, a one-way ANOVA for the ten community by grade groupings was performed for each of the four variables (Table 6). The mean square for error (MSE) values from these ANOVAs were used in two-sided t-tests. Contrasts of the following form were used in the t-tests:

$$\hat{L}_1 = \frac{\bar{x}(gr4A) + \bar{x}(gr6A)}{2} - \frac{\bar{x}(gr4B) + \bar{x}(gr6B)}{2}$$

where $\bar{x}(gr4A)$ and $\bar{x}(gr6A)$ were mean values for grades 4 and 6 in one community;

$\bar{x}(gr4B)$ and $\bar{x}(gr6B)$ were mean values for grades 4 and 6 in another community;

and $\hat{L}_1$ was the contrast used in each t-test to test for community differences in the dietary intake variables.

There were ten contrasts for each intake variable. The values used for the intake variables did not include vitamin A and energy contributions from the school food supplement, so that data from all ten community by grade groupings were comparable. Each contrast compared the unweighted mean intake for grade 4 and grade 6 children in one community with that of another community.

For hypotheses B.1.a to B.1.d, tests for the school supplement effect on the dietary intake variables, a one-way ANOVA was performed for each of the four variables. Eight community by grade groupings, excluding those from Brochet, were used (Table 6). The MSE values from the ANOVAs were used in one-sided t-tests which involved contrasts of the following form:

$$\hat{L}_2 = \frac{[\bar{x}(gr4CR) - \bar{x}(gr6CR)] + [\bar{x}(gr4ML) - \bar{x}(gr6ML)]}{2} - \frac{[\bar{x}(gr4CL) - \bar{x}(gr6CL)] + [\bar{x}(gr4BA) - \bar{x}(gr6BA)]}{2}$$

where $\bar{x}(gr4CR)$ and $\bar{x}(gr6CR)$ were mean values for grades 4 and 6 in Crane River;

$\bar{x}(gr4ML)$ and $\bar{x}(gr6ML)$ were mean values for grades 4 and 6 in Moose Lake;

$\bar{x}(gr4CL)$ and $\bar{x}(gr6CL)$ were mean values for grades 4 and 6 in Cormorant Lake;

$\bar{x}(gr4BA)$ and $\bar{x}(gr6BA)$ were mean values for grades 4 and 6 in Barrows Junction;

and $\hat{L}_2$ was the contrast used in each t-test to test for the school supplement effect on the dietary intake variables.

There was one contrast for each intake variable. The values used for the intake variables included the vitamin A and energy contributions from the school food supplement. The contrasts compared the dietary intake variables for children in Crane River and Moose Lake, where the grade 4 children received their regular school food supplement on the day of the interview, with those for children in Cormorant Lake and Barrows Junction, where the grade 4 children did not receive their regular school supplement. Thus for each variable, the effect of the school supplement contribution on the total intake was measured.

Corrected means for each community were calculated by subtracting the mean intake for the grade 6 children from the mean intake for the grade 4 children. In this manner, the grade 6 means were used as controls in order to eliminate possible effects due to community differences. The corrected means for the communities who received their regular school supplement (Crane River and Moose Lake) were then averaged and compared to the average of the corrected means for the communities who did not receive it (Cormorant Lake and Barrows Junction). Two-sided t-tests (grade 4 vs grade 6) were performed on Brochet intake variables for comparison.

The remaining hypotheses were tested in pairs (i.e. A.2.a/B.2.a, A.3.a/B.3.a, and A.3.b/B.3.b). In other words, the effects of the independent variables (community and school supplement) were tested for simultaneously for each biochemical and clinical indicator (Table 7). The confounding variable of whether or not a concentrated form of vitamin A had any effect, was also included in each test. An unbalanced three-way ANOVA (community x school food supplement x vitamin A concentrate) was performed for each pair of hypotheses. Data from Brochet were not included in the three-way ANOVAs. In order to test for community differences (hypotheses A.2.a, A.3.a, and A.3.b) with Brochet included, two-way ANOVAs (community x vitamin A concentrate) were performed on the grade 4 data alone. Two-way ANOVAs (grade x vitamin A concentrate) were performed on Brochet data to use for comparison.

The serum vitamin A and dark adaptation test data for all grade 4 children were considered to be comparable. It was assumed that the grade 4 children in all communiuties would periodically miss receiving their school food supplement; thus serum vitamin A levels and dark adaptation test scores would be affected similarly in all communities.

Simple linear regression analyses were used to test for relationships between pairs of dark adaptation test, serum vitamin A, and intake variables. In addition, regressions of the dark adaptation variables versus the natural logs of the intake variables and serum vitamin A were calculated. For each comparison, the data were divided into three or four groups depending on significances found in the testing of the hypotheses and whether or not the children entitled to the school food supplement received it. In each case, regressions were performed for data within each group and for all data together. The coefficient of correlation (r) and the coefficient of determination (r^2) were reported as indicators of the degree of relationship between pairs of variables. The coefficient of determination can have values from zero to one and represents the proportionate reduction in the variability of each variable that is associated with the use of the other variable in the model (Neter and Wasserman, 1974).

For a general description of the vitamin A status using the dietary data, the percentage of "true deficients" was determined for each community by grade grouping. The probabilities of deficiency proposed by Anderson (1980) were used. The vitamin A intakes from all sources were first expressed as percentages of the recommended intakes. Then the number of individuals consuming 100% or more, 85-99%, 70-84%, 55-69%, 40-54% and less then 40% of the recommended intake were determined. These numbers were multiplied by probabilities of deficiency of 0, 0.07, 0.31, 0.69, 0.92, and 1.00 respectively. The resulting products were added to give the number of "true deficients," the sum then being divided by the total number of individuals, and multiplied by 100 to give the percentage of "true deficients."

All ANOVA procedures were performed using the general linear models procedure of the Statistical Analysis System (Helwig and Council, 1979). The t-tests involving contrasts to test for community and school food supplement effects on the dietary indicators were computed by hand. The Bonferroni method for multiple comparisons was used to make decisions on the significance of the community differences (Neter and Wasserman, 1974). (See Appendix 7 for the equations used.) A method suggested by Kleinbaum and Kupper (1978) was used for the interpretation of the unbalanced multiple-way ANOVAs. Interaction effects were determined with the main effects (eg. community, school food supplement, and vitamin A concentrate) already in the model. When no interaction effects were found, each main effect was determined with the remaining main effects already in the model. The regression analyses were performed using program 1R of the Biomedical Computer Programs P-series (Dixon and Brown, 1979). All statistical decisions were made using $p<0.05$ as the level of significance.

Non-parametric statistical procedures were considered for use with the data, but were rejected for the following reasons: 1) non-parametric procedures do not use all the information contained in measurements with a ratio scale as were collected in the present study, therefore they are less powerful than parametric procedures; and 2) parametric statistics are robust enough to handle some non-normality of distribution and heterogeneity of variances.

RESULTS

Confounding Variables

Comparison of the histograms of the vitamin A and energy intake residuals for the interviewers indicated no marked differences (Figures 9 and 10, Appendix 8). There were no major differences among the interviewers with respect to the variability of results, and no interviewer appeared to have generally higher (or lower) residuals than any other interviewer. It was not possible to test for interviewer change over time, however, it was felt that the training course minimized this variation.

The overall mean DAT and bestDAT values for children who did not wear their prescribed glasses were slightly greater than those for children who needed no vision correction or wore their glasses (DAT: 241 vs 230 sec; and bestDAT: 205 vs 199 sec respectively). However, comparisons of mean values when these children were grouped according to their community, grade, and whether or not they consumed a vitamin A concentrate showed no consistent differences. Approximately half of the mean values were higher for those children not wearing their prescribed glasses and half were lower, for both the DAT and bestDAT variables (Tables 26 to 29, Appendix 9). In addition all children were able to find hidden objects in the line drawings during light adaption. Therefore it was considered that failure to wear prescribed glasses had no significant effect on the dark adaptation test variables.

There were no interaction effects detected in any of the multiple-way ANOVAs, thus the main effects (independent and confounding variables) will be discussed separately. A significant effect on serum vitamin A levels due to the ingestion of a concentrated form of vitamin A was found both in the three-way ANOVA (community x school supplement x vitamin A concentrate) done on all data excluding that from Brochet ($p<0.003$), and in the two-way ANOVA (community x vitamin A concentrate) done on the grade 4 data ($p<0.04$). Although the effect was not significant at the 0.05 level in the two-way ANOVA (grade x vitamin A concentrate) done on the Brochet data, a marginal p value between 0.05 and 0.10 was found. In each case the serum vitamin A level for those children who consumed a vitamin A concentrate was higher than that for those who did not. The respective means for the three tests were 61 vs 56; 57 vs 55; and 56 vs 52 μg/100 ml. Table 14 (page 84) shows a summary of the serum vitamin A data used in the tests.

None of the ANOVAs for either of the dark adaptation test variables showed any significant effect due to the consumption of a vitamin A concentrate. Summaries of the DAT and bestDAT data used in the analyses are shown in Tables 15 and 16 (pages 85 and 86), respectively.

General Vitamin A Status

The percentages of "true deficients," using both the Canadian recommendations and the weight recommendations for calculations, are shown in Tables 8 and 9 respectively. The values using the weight recommendations were lower than those using the Canadian recommendations, due to the smaller safety margin in the weight recommendations. However, in both cases, the percentages of "true deficients" suggested that there was a high risk of vitamin A deficiency among the children, with the possible exception of the grade 4 children in Moose Lake. For the whole group of 133 children, 45 and 35% were considered to be "true deficients" using the Canadian and weight recommendations, respectively.

Tables 18 and 19 (pages 87 and 88) show the mean vitamin A intakes for the ten community by grade groupings, expressed as percentages of the Canadian and weight recommendations. They suggested less risk of deficiency than the percentages of "true deficients." The mean intakes for grades 4 and 6 children in Crane River and grade 6 children in Moose Lake

Table 8. Percentage of "true deficients" calculated using the Canadian recommendations for the community by grade groupings; %, (n).

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	68 (12)	15 (11)	31 (14)	35 (14)	25 (15)
Grade 6	80 (14)	51 (13)	50 (12)	58 (14)	32 (14)

Table 9. Percentage of "true deficients" calculated using the weight recommendations for the community by grade groupings; %, (n).

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	67 (12)	8 (11)	19 (14)	19 (14)	21 (15)
Grade 6	63 (14)	41 (13)	45 (12)	43 (14)	22 (14)

and Barrows Junction were below both the Canadian and weight recommendations, whereas the mean intakes for all other groups of children were similar to or greater than the recommended levels. The mean intake for all 133 children was 93% of the Canadian recommendation and 109% of the weight recommendation.

Anderson and coworkers (1982) reported that comparison of the mean intake for a group of individuals with the recommended intake underestimates the degree of deficiency since it ignores the distribution of intakes among individuals. They recommended the use of "true deficients," since the calculation takes into account variabilities in intakes as well as requirements. However, they did report that the use of 24-hour dietary data would inflate the number of "true deficients," since food intakes measured over a 24-hour period are more variable in nutrient content than are usual intakes. Large day-to-day variations in vitamin A intakes are common since it is found in considerable amounts in only a few foods. In light of these considerations, it is difficult to ascertain the true risk of deficiency using the dietary data alone. However, the dietary data did seem to indicate some risk of vitamin A deficiency among the children.

Table 14 (page 84) is a summary of the serum vitamin A levels of the children in this study. The mean ± SEM level for the total group of 118 children was 56 ± 1 μg/100 ml. No child was found to have a serum vitamin A level below 40 μg/100 ml. For nutrition surveys among free-living populations, both 30 and 20 μg/100 ml have been used as levels below which some risk of vitamin A deficiency was considered to be present (Sauberlich et al., 1974a). Impaired dark adaptation attributable to vitamin A deficiency has been reported among some individuals with serum vitamin A levels between 30 and 39 μg/100 ml, but not at 40 μg/100 ml or over (Carney and Russell, 1980; and Sauberlich et al., 1974b). Thus no children at the time of this study were considered to be at risk of vitamin A deficiency as measured by serum vitamin A levels.

No definitive standards have yet been set for adequate scores for the rapid dark adaptation test. Thornton, who originally described the test in 1977, suggested that an adult with normal dark adaptation ability should be able to separate the blue and red chips within 150 to 180 sec. However, he allowed for one mismatch for each colour, whereas the present study measured the time taken for the correct separation of all discs.

The results of several studies which also measured the time for the correct separation of all discs are shown in Appendix

10 (Kim and Solomons, 1983; Sevenhuysen, 1984; Solomons et al., 1982; and Vinton and Russell, 1981). Due to procedural variations, they are not strictly comparable to values found in the present study. Researchers have found that the rapid dark adaptation test performance time was affected by the type of disc used (Sevenhuysen, 1984), the intensity of the light source used for light adaptation (Vinton et al., 1980), and the duration of the light adaptation period (Sevenhuysen, 1984; and Vinton et al., 1980).

The mean DAT and bestDAT values for groups of children in the present study are shown in Tables 15 and 16 (pages 85 and 86). For the total sample of 138 children, the mean ± SEM values were 232 ± 6 sec for the DAT and 200 ± 6 sec for the bestDAT. These values were higher than those previously reported for healthy children and young adults who performed the test using matte finish discs (Kim and Solomons, 1983; Sevenhuysen, 1984; Solomons et al., 1982; and Vinton and Russell, 1981), but lower than those found for healthy young adults who performed the test using reflective finish discs like those used in the present study (Sevenhuysen, 1984).

The differences between the test scores in the present study and those reported for children in earlier studies were not of a magnitude previously reported to be associated with vitamin A deficiency (Vinton and Russell, 1981). The differences may have been largely due to the type of disc used. Discs with a reflective finish were used in the present study, whereas matte finish discs were used in previous studies. At certain angles the specular reflection of the discs used in the present study may have been misinterpreted as a brighter grey colour. Sevenhuysen (1984) found that healthy individuals were able to distinguish matte finish Munsell discs on average in less than two-thirds the time required for reflective finish discs like those used in the present study.

Independent Variable = Community

The results of the tests for community differences in the dietary indicators (hypotheses A.1.a to A.1.d) are illustrated in Figure 2. The mean values for the ten community by grade groupings used in the contrasts for testing the hypotheses are shown in Tables 10 to 13. No significant differences were found among the communities of Barrows Junction, Cormorant Lake, Moose Lake, and Brochet for any of the intake variables. The diets were of a significantly lower vitamin A density in Crane River than in any of the other four communities. The mean values for the other three intake variables were also lower in Crane River than in any other community, however, they were significantly

Figure 2. Linear plots of mean community values for the four vitamin A intake variables. Means joined by lines were not significantly different. CR = Crane River. BA = Barrows Junction. CL = Cormorant Lake. ML = Moose Lake. BR = Brochet.

p values for significant community differences

A. Intakes in RE.

CR 390 — BA 694 — CL 735 — ML 816 — BR 817

BR-CR $p < 0.01$
ML-CR $p < 0.04$

B. Intakes expressed as percentages of the Canadian recommendations.

CR 50 — BA 89 — CL 98 — BR 104 — ML 105

BR-CR $p < 0.02$
ML-CR $p < 0.04$

C. Intakes expressed as percentages of the weight recommendations.

CR 62 — BA 103 — CL 117 — ML 118 — BR 124

BR-CR $p < 0.02$

D. Vitamin A densities in RE/100 kcal.

CR 19 — BA & BR 39 — CL & ML 46

ML-CR $p < 0.01$
CL-CR $p < 0.01$
BR-CR $p < 0.05$
BA-CR $p < 0.05$

Table 10. Vitamin A intake, excluding the contribution from the school supplement, expressed in retinol equivalents for the community by grade groupings; $\bar{x}$ ± SEM, (n).

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	375±98 (12)	945±175 (11)	693±84 (14)	780±148 (14)	816±102 (15)
Grade 6	405±45 (14)	687±165 (13)	777±198 (12)	607±114 (14)	819±121 (14)

One-way ANOVA and t-tests (see pages 62 and 64, formula $\hat{L}_1$) indicated that Crane River had significantly lower values than Brochet ($p<0.01$) and Moose Lake ($p<0.04$).

Table 11. Vitamin A intake, excluding the contribution from the school supplement, expressed as a percentage of the Canadian recommendation for the community by grade groupings; $\bar{x}$ ± SEM, (n).

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	51±14 (12)	129±25 (11)	99±12 (14)	103±18 (14)	107±14 (15)
Grade 6	49±6 (14)	80±19 (13)	97±25 (12)	75±13 (14)	102±15 (14)

One-way ANOVA and t-tests (see pages 62 and 64, formula $\hat{L}_1$) indicated that Crane River had significantly lower values than Brochet ($p<0.02$) and Moose Lake ($p<0.04$).

Table 12. Vitamin A intake, excluding the contribution from the school supplement, expressed as a percentage of the weight recommendation for the community by grade groupings; $\bar{x} \pm$ SEM, (n).

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	64±20 (12)	144±27 (11)	119±14 (14)	119±18 (14)	129±17 (15)
Grade 6	60±6 (14)	92±22 (13)	115±29 (12)	87±15 (14)	120±20 (14)

One-way ANOVA and t-tests (see pages 62 and 64, formula $\hat{L}_1$) indicated that Crane River had significantly lower values than Brochet ($p<0.02$).

Table 13. Vitamin A density, excluding the vitamin A and energy from the school supplement, expressed in RE/100 kcal for the community by grade groupings; $\bar{x} \pm$ SEM, (n).

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	18±4 (12)	55±9 (11)	53±7 (14)	41±9 (14)	37±5 (15)
Grade 6	21±4 (14)	36±8 (13)	39±8 (12)	37±6 (14)	41±6 (14)

One-way ANOVA and t-tests (see pages 62 and 64, formula $\hat{L}_1$) indicated that Crane River had significantly lower values than Moose Lake ($p<0.01$), Cormorant Lake ($p<0.01$), Brochet ($p<0.05$), and Barrows Junction ($p<0.05$).

different from only Moose Lake and/or Brochet.

The mean energy intakes, excluding that from the school food supplement were 1724, 1811, 1832, 2176, and 2188 kcal in Cormorant Lake, Moose Lake, Barrows Junction, Crane River, and Brochet, respectively. Thus as suggested by the statistical tests, the lower vitamin A intakes by children in Crane River were due to the choice of foods with a lower vitamin A density, not to the consumption of a smaller amount of food than that eaten in other communities.

Tests to assess community differences were also performed on data excluding vitamin A and energy contributions from moose, because it was a seasonal food source and other meats which may be substituted for it would not provide substantial amounts of vitamin A. The mean values of the four dietary indicators for the ten community by grade groupings are shown in Appendix 11. The vitamin A density of the diets in Crane River was significantly less than that of the diets in Cormorant Lake ($p<0.03$). No other significant differences were found among the communities for any of the dietary intake variables. However, the mean values for all intake variables remained the lowest in Crane River. Moose was not consumed by any children in Crane River, and it made significant contributions to the vitamin A intakes of children in the other communities.

No community differences were found for either the serum vitamin A level or the dark adaptation test variables (hypotheses A.2.a, A.3.a, and A.3.b). The three-way ANOVAs (community x school supplement x vitamin A concentrate) done on all data excluding that from Brochet showed no significant differences among Crane River, Moose Lake, Cormorant Lake, and Barrows Junction for the biochemical or clinical variables. In addition no significant community differences were found among any of the communities in the two-way ANOVAs (community x vitamin A concentrate) using all grade 4 data. Tables 14 through 16 are summaries of the serum vitamin A and dark adaptation test data.

Independent Variable = School Food Supplement

No significant differences were found in the intake variables between those children who received the school supplement and those who did not (hypotheses B.1.a to B.1.d). The t-tests done on the Brochet data for comparison also showed no significant differences. Since all children in Brochet received the school supplement, the lack of significant differences would support the use of grade 6 children as controls for the grade 4 children in the tests of the hypotheses. Tables 17 through 20 are summaries of the data used in these tests.

Table 14. Serum vitamin A levels in μg/100 ml of serum for the community by grade by vitamin A concentrate groupings; $\bar{x}$ ± SEM, (n).

		Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	No Vitamin Concentrate	57±3 (7)	56±2 (10)	53±2 (7)	59±2 (7)	51±2 (7)
	Vitamin Concentrate	55±-- (1)	66±10 (2)	58±2 (6)	57±1 (3)	56±3 (8)
Grade 6	No Vitamin Concentrate	52±3 (10)	57±3 (11)	55±3 (7)	57±2 (11)	52±2 (10)
	Vitamin Concentrate	--- (0)	70±-- (1)	61±3 (5)	71±3 (2)	56±2 (3)

Three-way ANOVA on all data except Brochet (see page 63) indicated a significant vitamin concentrate effect ($p<0.003$).
Two-way ANOVA on all grade 4 data (see page 63) indicated a significant vitamin concentrate effect ($p<0.04$).
Two-way ANOVA on Brochet data (see page 63) showed a marginally significant vitamin concentrate effect ($p<0.08$).

Table 15. DAT[a] times in seconds for the community by grade by vitamin A concentrate groupings; $\bar{x}$ ± SEM, (n).

		Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	No Vitamin Concentrate	269±25 (12)	249±24 (12)	232±24 (9)	223±21 (9)	257±19 (7)
	Vitamin Concentrate	246±2 (2)	219±26 (2)	213±18 (6)	296±28 (4)	259±24 (8)
Grade 6	No Vitamin Concentrate	201±15 (13)	202±20 (10)	188±18 (8)	215±13 (13)	246±28 (11)
	Vitamin Concentrate	181±-- (1)	158±42 (2)	244±49 (5)	257±43 (2)	314±110 (2)

[a]DAT time for one individual was the average time of the two recorded trials

Three-way ANOVA on all data except Brochet (see page 63) indicated that grade 4 children took significantly longer to complete the test than grade 6 children ($p<0.004$).

Table 16. BestDAT[a] times in seconds for the community by grade by vitamin A concentrate groupings; $\bar{x} \pm SEM$, (n).

		Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	No Vitamin Concentrate	219±22 (12)	219±20 (12)	213±25 (9)	184±21 (9)	224±18 (7)
	Vitamin Concentrate	222±14 (2)	214±26 (2)	197±21 (6)	262±27 (4)	230±27 (8)
Grade 6	No Vitamin Concentrate	174±14 (13)	163±14 (10)	144±15 (8)	194±12 (13)	207±22 (11)
	Vitamin Concentrate	171±-- (1)	138±38 (2)	194±34 (5)	241±52 (2)	268±100 (2)

[a]BestDAT time for one individual was the shortest time of the two recorded trials.

Three-way ANOVA on all data except Brochet (see page 63) indicated that grade 4 children took significantly longer to complete the test than grade 6 children ($p<0.002$).

Table 17. Vitamin A intake in retinol equivalents for the community by grade groupings; $\bar{x}$ ± SEM, (n).

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	413±100 (12)	1064±177 (11)	693±84 (14)	780±148 (14)	868±100 (15)
Grade 6	405±45 (14)	687±165 (13)	777±198 (12)	607±114 (14)	907±121 (14)

Table 18. Vitamin A intake expressed as a percentage of the Canadian recommendation for the community by grade groupings; $\bar{x}$ ± SEM, (n).

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	57±14 (12)	145±26 (11)	99±12 (14)	103±18 (14)	113±14 (15)
Grade 6	49±6 (14)	80±19 (13)	97±25 (12)	75±13 (14)	113±15 (14)

Table 19. Vitamin A intake expressed as a percentage of the weight recommendation for the community by grade groupings; $\bar{x} \pm$ SEM, (n).

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	70±20 (12)	163±27 (11)	119±14 (14)	119±18 (14)	137±17 (15)
Grade 6	60±6 (14)	92±22 (13)	115±29 (12)	87±15 (14)	133±21 (14)

Table 20. Vitamin A density in RE/100 kcal for the community by grade groupings; $\bar{x} \pm$ SEM, (n).

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	19±4 (12)	56±8 (11)	53±7 (14)	41±9 (14)	39±5 (15)
Grade 6	21±4 (14)	36±8 (13)	39±8 (12)	37±6 (14)	44±6 (14)

The three-way ANOVA (community x school supplement x vitamin A concentrate) done on all serum vitamin A data excluding that from Brochet showed no significant differences in the serum level between those who regularly received the school supplement and those who did not (hypothesis B.2.a). No differences were found between grade 4 and grade 6 children in Brochet either. This would support the use of grade 6 children as controls for grade 4 children in testing the hypothesis (B.2.a). Table 14 shows a summary of the data used in these tests.

The tests for the effect of the consumption of the school food supplement on the clinical indicators of vitamin A status (hypotheses B.3.a and B.3.b) showed counterintuitive results. The three-way ANOVAs (community x school supplement x vitamin A concentrate) for both the DAT and bestDAT variables indicated that the grade 4 children (those who regularly received the school supplement) took significantly longer to complete the test than the grade 6 children (those who did not regularly receive the supplement). The respective means for the grade 4 and grade 6 children were DAT: 245 and 207 sec ($p<0.005$), and bestDAT: 213 and 175 sec ($p<0.002$). No significant differences in either variable were found between the grades in the two-way ANOVAs (grade x vitamin A concentrate) done on the Brochet data. This could have been due to the smaller sample size.

Relationships Between Variables

For the comparisons of serum vitamin A and intake variables the data were grouped into four groups: 1) children who did not receive their regular school food supplement and who did not take a vitamin A concentrate; 2) children who did not receive their regular school food supplement and who took a vitamin A concentrate; 3) all other children who did not take a vitamin A concentrate; and 4) all other children who took a vitamin A concentrate. There were three groups used for regression analyses for dark adaptation test variables and intake variables: 1) grade 4 children who did not receive their regular school food supplement; 2) grade 4 children who received their regular school food supplement; and 3) all grade 6 children. For the comparisons of the dark adaptation test variables and serum vitamin A, four groups were used: 1) grade 4 children who did not take a vitamin A concentrate; 2) grade 4 children who took a vitamin A concentrate; 3) grade 6 children who did not take a vitamin A concentrate; and 4) grade 6 children who took a vitamin A concentrate. Table 21 is a summary of the groupings used for each relationship.

These groupings were chosen for several reasons. Whether

Table 21. Characteristics of groups used in the analyses of relationships between variables. (Each letter designates one group of subjects.)

Relationship Tested	Grade 4				Grade 6	
	No School Supplement		School Supplement		School Supplement[a]	
	No Vitamin Conc.	Vitamin Conc.	No Vitamin Conc.	Vitamin Conc.	No Vitamin Conc.	Vitamin Conc.
Serum Vitamin A vs Intake Variables	A	B	C	D	C	D
DAT and BestDAT vs Intake Variables	E	E	F	F	G	G
DAT and BestDAT vs Serum Vitamin A	K	L	K	L	M	N

[a]All children in grade 6 either received their regular school supplement or were not entitled to it.

the children took a vitamin A concentrate or not had a significant effect on the serum vitamin A level. Grade had a significant effect on the dark adaptation variables. In addition, it was thought that there may have been an effect on intakes depending on whether those children entitled to the school food supplement received it or not on the day of the interview.

Based on these criteria, the data were divided according to whether the subjects took a vitamin A concentrate and whether they received their regular school food supplement, for the relationships between serum vitamin A and the intake variables. Subjects who were not entitled to the supplement (grade 6 children in Crane River, Moose Lake, Cormorant Lake, and Barrows Junction) were grouped with their counterparts who received the school supplement on the day of the interview, since both conditions were the usual occurence. For the relationships between the dark adaptation test variables and the intake variables, the data were divided by grade and whether the children received their school food supplement, with those not entitled to the supplement being grouped with those who received it on the day of the interview. Groupings for the relationships between the dark adaptation test variables and serum vitamin A were based on grade and whether the children took a vitamin A concentrate.

Table 35, Appendix 12 shows the results of the tests for relationships between serum vitamin A and the four intake variables. No significant relationships were found between serum vitamin A and any intake variable when the data were divided into the four groups or when they were considered as a whole. The coefficient of determination (r^2) values ranged from 0.001 to 0.081, with most being less than 0.025. Thus in most cases, less than 2.5% of the total variability in each variable was associated with the use of the other variable in the model. In addition, scatter plots of the serum vitamin A values versus the intake variables did not suggest any relationships at the lower values of any of the indicators.

Results of the tests for relationships between the dark adaptation test variables and the intake variables, and between the dark adaptation test variables and the natural logs of the intake variables are shown in Tables 36 to 39, Appendix 12. There were no relationships that were significant. For the grade 4 children who received their regular school supplement, positive (counterintuitive) relationships approached significance for tests between DAT values and the intakes expressed as percentages of the weight recommendations, between bestDAT values and the three intake variables other than vitamin A density, and between bestDAT values and the natural logs of the intake variables other than vitamin A density. The p values for these relationships ranged between 0.017 and 0.049. However, they were values for individual tests and a large number of relationships were considered. In addition, the r^2 values for these tests ranged from 0.104 to 0.149, indicating that in each case less than 15% of the variability in the variables was accounted for by their mutual dependence.

Positive relationships between the bestDAT values and the natural logs of the two intake variables expressed as percentages of recommended intakes also approached significance when the data for all children were considered as a whole. However, the r^2 values for these relationships were lower than those found for the grade 4 children who received their school supplement, representing less than 3.5% of the total variation.

Scatter plots of the dark adaptation test variables versus the linear intake variables for all of the children did not suggest any relationships at the lower values. However, scatter plots of the dark adaptation test variables versus the natural logs of the intake variables suggested positive relationships at the lower values, with the relationships involving the bestDAT variable being the strongest.

Tables 40 and 41, Appendix 12 show the results of tests for relationships between the dark adaptation test variables and serum vitamin A, and between the dark adaptation test variables and the natural log of serum vitamin A. No significant relationships were found for any grouping or when the data were considered as a whole, and the r^2 values ranged from 0 to 0.059, indicating that in all cases less than 6% of the total variability in each variable was accounted for by the use of the other variable in the model. Scatter plots between the variables did not suggest any relationship at the lower values of any of the variables.

Sources of Vitamin A Intakes

Table 22 shows the sources of vitamin A for each grade in all of the communities. The major source of vitamin A in all of the communities was the store. Crane River children received, on the average, less vitamin A from this source than the children in the other communities. Information on the vitamin A density of the intakes from various sources (Table 23) suggested that the lower vitamin A intake from the store in Crane River was due to the choice of foods with a lower vitamin A density, not because less food was consumed than that eaten in the other communities. Total energy intakes recorded supported this theory, since the mean energy intake in Crane River was among the highest found.

Another major difference between Crane River and the other

Table 22. Vitamin A intake in retinol equivalents from various sources for the community by grade groupings; $\bar{x}$ ± SEM, (n).

		Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	Store	354±91	515±154	506±82	473±74	674±77
	School supplement	38±8	120±13	0	0	52±11
	School purchase	10±7	0	0	0	19±13
	Wild	0	430±141	123±42	126±59	124±43
	Local farm or garden	8±8	0	64±55	147±103	0
	Unknown	4±4	0	0	35±35	0
		(12)	(11)	(14)	(14)	(15)
Grade 6	Store	405±45	381±139	484±101	430±107	702±112
	School supplement	0	0	0	0	89±0
	School purchase	0	0	0	0	0
	Wild	0	306±146	114±60	68±36	117±73
	Local farm or garden	0	0	180±175	0	0
	Unknown	0	0	0	108±77	0
		(14)	(13)	(12)	(14)	(14)

Table 23. Vitamin A density in RE/100 kcal from various sources for the community by grade groupings; $\bar{x}$ ± SEM, (n).

		Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	Store	19±5 (11)	35±10 (11)	39±6 (14)	28±4 (13)	32±4 (15)
	School supplement	46±0 (8)	66±6 (11)	--- (0)	--- (0)	117±0 (9)
	School purchase	22±13 (4)	--- (0)	--- (0)	0±-- (1)	73±0 (2)
	Wild	0±0 (2)	150±26 (10)	196±0 (6)	112±33 (7)	196±0 (8)
	Local farm or garden	15±15 (4)	--- (0)	975±827 (3)	209±111 (5)	--- (0)
	Unknown	3±-- (1)	--- (0)	--- (0)	29±-- (1)	--- (0)
Grade 6	Store	22±4 (14)	20±6 (13)	27±6 (12)	30±5 (12)	35±5 (14)
	School supplement	--- (0)	--- (0)	--- (0)	--- (0)	117±0 (14)
	School purchase	0±0 (2)	--- (0)	--- (0)	--- (0)	--- (0)
	Wild	0±0 (3)	180±16 (5)	163±33 (6)	112±40 (7)	181±15 (3)
	Local farm or garden	8±8 (2)	--- (0)	1716±1672 (2)	0±-- (1)	--- (0)
	Unknown	0±-- (1)	--- (0)	--- (0)	63±29 (2)	--- (0)

communities was that the Crane River children received no vitamin A from wild sources. Although moose was the only wild source of vitamin A, it was consumed by a number of children in each of the other communities. Since moose has a high vitamin A density (196 RE/100 kcal), it provided considerable amounts of vitamin A in the diets of those children who consumed it. The greatest intake of moose was recorded among the children in Moose Lake.

A small contribution to the differences between Crane River, and Cormorant Lake and Barrows Junction may have been due to a lower amount of vitamin A activity being provided from locally produced foods in Crane River. Similar numbers of children consumed locally produced foods in all three of the communities, however, the choices in Crane River showed lower vitamin A concentrations. Appendix 13 shows a summary of the vitamin A densities of the locally produced foods that were eaten.

Food Group Contributions to Vitamin A Intakes

Table 24 shows the percentage contributions of food groups to the vitamin A intakes in the five communities, and Table 43, Appendix 14 shows the absolute contributions in retinol equivalents. The vitamin A in soups was primarily from the

Table 24. Percentage contribution of food groups to the vitamin A intake for all children in each community; %, (n).

Food Group	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Dairy products					
-total excl. school supp.	27	11	16	15	17
-school supp. contribution	4	5	0	0	8
Wild game and fish	0	42	16	14	13
Eggs	15	4	14	13	25
Domestic meat, poultry, and fish	1	1	1	1	3
Vegetables including dried legumes	2	15	24	12	5
Soups	15	5	5	20	5
Fats and oils	29	9	18	17	18
Fruits and fruit products	3	1	3	3	3
Grain products	1	1	1	1	tr
Misc. products incl. sugars, mixtures, nuts, and seeds	3	7	2	3	2
	(26)	(24)	(26)	(28)	(29)

vegetable content, thus their contribution will be considered together with that from other vegetables. In all communities, five food groups (dairy products, wild game, eggs, vegetables and soups, and fats and oils) provided 10% or more of the vitamin A in the diets, except in Crane River where no moose was consumed and in Moose Lake where eggs provided only 4% and fats and oils contributed only 9% of the vitamin A. However, the relative importance of these food groups varied among the communities.

Among the four communities where no significant differences in vitamin A intakes were found, Cormorant Lake and Barrows Junction had similar dietary compositions. The vegetables and soups group was the primary source of vitamin A; fats and oils, dairy products, wild game, and eggs were secondary sources.

In Brochet, eggs were the primary source of vitamin A, providing approximately twice as much vitamin A as in Cormorant Lake and Barrows Junction. Conversely the vegetables and soups group provided only one third as much vitamin A as in Cormorant Lake and Barrows Junction. Other food groups provided similar percentage contributions to the vitamin A intake, although the absolute contributions (Table 43, Appendix 14) of fats and oils, and dairy products excluding that from the school food supplement were slightly higher since the total vitamin A intake in Brochet was slightly higher. (Analyses of community differences were based on values excluding the vitamin A contribution from the school food supplement.)

The dietary composition in Moose Lake was different from that in the other three communities mentioned. Moose was the primary source of vitamin A, providing approximately three times as much vitamin A as in the three other communities. The vegetables and soups group was a secondary source, providing less vitamin A than in Cormorant Lake and Barrows Junction but more than in Brochet. Eggs, fats and oils, and dairy products excluding the school food supplement all provided less vitamin A than in the other three communities.

A major difference in the vitamin A intake between Crane River and the other communities was the lack of contribution from moose. The percentage figures suggested a similar contribution from eggs as in Cormorant Lake and Barrows Junction, however, because of the lower total vitamin A intake in Crane River, a smaller absolute contribution from eggs resulted in a similar percentage figure. Similarly the absolute contribution from vegetables and soups was lower in Crane River than in the other communities. The primary sources of vitamin A in Crane River were fats and oils, and dairy products. Their absolute contributions were similar to those in Cormorant Lake and Barrows Junction, although the percentage figures were higher in Crane River.

The mean vitamin A intake from dairy products excluding that from the school supplement was approximately equal to that provided by one serving, or 250 ml of milk for most groups of children (Table 43, Appendix 14). Grade 4 children in each community generally consumed the equivalent of slightly more than one serving, whereas grade 6 children consumed slightly less. Grade 4 children in Moose Lake were an exception in that their mean intake from dairy products excluding the school food supplement was lower than that of the grade 6 children. Another exception occurred in Brochet where both the grade 4 and grade 6 children had higher intakes from dairy products excluding that from the school supplement than their counterparts in the other communities. Grade 4 children consumed over 1.5 servings of dairy products other than the supplement and grade 6 children consumed slightly more than one serving.

The mean vitamin A intake provided by the school supplement ranged from that which would be provided in less than one half of a serving of milk to that provided by approximately one serving of milk. The intake depended on the number of children consuming the supplement and the composition of the supplement offered on the day of the interview. In Crane

River, where the supplement was offered at noon, one-third of the grade 4 children did not consume it. In Brochet, the supplement was distributed in the morning before classes began and 80% of the students reported consuming it. All of the grade 4 children consumed the supplement in Moose Lake where it was distributed mid-morning during class time. In Moose Lake the supplement was more varied and substantial than in the other communities, more often incorporating cheese, juice, crackers, and peanuts. On the day of the interview, some children in Moose Lake reported receiving both milk and cheese, whereas children in Crane River and Brochet received milk only.

DISCUSSION

Confounding Variables

No major differences in dietary intake data were found among the interviewers, the failure to wear prescribed glasses was not considered to have a significant effect on the dark adaptation test variables, and the consumption of a vitamin A concentrate had no significant effect on the dark adaptation test variables. The effect of the consumption of a vitamin A concentrate on serum vitamin A levels was controlled for by entering it into the multiple-way ANOVAs used to test the hypotheses involving serum vitamin A. Serum levels were significantly higher for those children who consumed a vitamin A concentrate than for those who did not. In a study of the nutritional status of preschool children in the United States, Owen and co-workers (1974) also found that children who took a vitamin A concentrate had significantly higher plasma vitamin A levels than those who did not. These findings are in agreement with other studies which found that serum vitamin A levels were elevated after the ingestion of a single dose of a vitamin A concentrate (Kagan, 1953; Kimble, 1939; McCoord et al., 1948; Molla et al., 1983; and Popper et al., 1948).

General Vitamin A Status

The dietary data suggested that some children were at risk of vitamin A deficiency. However, no children had serum vitamin A levels indicative of vitamin A deficiency, and although the mean times taken to complete the dark adaptation test were longer than those found previously for healthy children, (Solomons et al., 1982) the differences were not of a magnitude previously reported to be associated with vitamin A deficiency (Vinton and Russell, 1981). It is likely that the type of disc used for the dark adaptation test was a major contributor to the longer test times found in the present study.

Several factors may have contributed to the failure to find relationships between the dietary findings, and the biochemical and clinical findings. Twenty-four hour recall data are more variable than usual intakes and thus lead to the incorrect classification of some individuals as "true deficients." For vitamin A, which is not uniformly distributed throughout the food supply, day-to-day variations in individual intakes are especially large. It is also possible that the children had lower vitamin A intake requirements than those specified by either set of recommendations. The dietary data presented here may therefore have overestimated the proportion of children with diets containing insufficient vitamin A.

Another factor is the homeostatic nature of serum vitamin A regulation whereby liver stores of vitamin A are mobilized to maintain serum levels at physiologically adequate levels. It is possible that the vitamin A intakes of the children during the months preceding the time of the study were sufficient enough to allow liver storage of the vitamin, and that the liver stores were being drawn upon at the time of the study to maintain normal serum vitamin A levels and dark adaptation function. Vitamin A status may be different at the end of the winter if this explanation were to be confirmed.

In studies previously carried out among Indian populations the dietary intakes were similar to those in the present study. Mean intakes were often similar to recommended intakes, but substantial proportions of individuals had intakes below the recommendations (Table 2, page 8). However, other researchers found lower mean or median serum vitamin A levels than in the present study, and some individuals in each study were found to have serum levels associated with a moderate or high risk of vitamin A deficiency (Table 3, page 29).

Community Differences

The diets of children in Crane River were of a significantly lower vitamin A density than in any of the other four communities. The means for the other three intake variables were also lower in Crane River than in the other communities, although they were significantly different from only Moose Lake and/or Brochet. When the vitamin A and energy contributions from moose were excluded, the vitamin A density of the diets in Crane River was significantly lower than that in Cormorant Lake. Although no other differences were significant, the mean values for all intake variables remained lowest in Crane River.

Stepien (1978) found that among Indian reserves in British Columbia, vitamin A intakes were lower in isolated reserves than they were in non-isolated reserves. Differences in degree of isolation among the communities in the present study were not as marked as in the study by Stepien, however, the most isolated community, Brochet, had vitamin A intakes among the highest for the five communities, whereas Crane River, a semi-isolated community, had the lowest intakes.

Gillis (1976) found, as did the present study, that vitamin A intakes did not have a simple relationship with degree of isolation. She grouped 11 northern Saskatchewan communities into 4 categories. Although she found that the communities with the greatest access to food supplies, and medical and media services had the highest intakes, those with the next best level of access had the lowest intakes, whereas the two categories with the lowest levels of access had intakes between the two.

No differences were found among the communities in the present study for either the serum vitamin A level or the dark adaptation test variables. Work by Hoffer and coworkers (1981) suggested that among adult Indians living in isolated areas, there was a greater percentage of individuals at risk of vitamin A deficiency than there was among those living close to urban areas. In the present study, the lack of differences among the communities is in keeping with the finding that no children were considered to be at risk of vitamin A deficiency as measured by biochemical and clinical indicators.

Although no conclusive evidence of vitamin A deficiency was suggested by the biochemical and clinical indicators of vitamin A status, the diets of the children, especially those in Crane River, could have been improved at the time of the study. Most of the vitamin A in the diets of the children in all of the communities was provided from store-bought foods. Children in Crane River consumed, on the average, less vitamin A from this source than the children in the other communities. Vitamin A density and energy intake data indicated that the lower vitamin A intakes in Crane River were due to the choice of foods with a lower vitamin A density, not to the consumption of a smaller amount of food than that eaten in other communities.

Another major difference between Crane River and the other communities was that children in Crane River received no vitamin A from wild sources. Moose was the only wild source consumed which contained vitamin A, however, it provided considerable amounts of vitamin A to the diets of children in the other communities, especially in Moose Lake. The relatively high dependence on moose as a source of vitamin A in Moose Lake may be a cause for concern because it is a seasonal food and most other meats which may be substituted for it do not provide substantial amounts of vitamin A. However, eggs were consumed less often in Moose Lake than in the other communities and could be a substitute which would provide vitamin A when moose was not available.

Locally produced foods contributed more vitamin A to the diets of the children in Cormorant Lake and Barrows Junction than in the other communities. In Crane River, a similar number of children consumed locally produced foods as in Cormorant Lake and Barrows Junction, however, the choices showed lower vitamin A concentrations. Community gardening was begun in Cormorant Lake during the year of the study and may have been a factor in the finding of a greater vitamin A contribution from vegetables than in the other communities.

In all communities the intake of dairy products was low in comparison to the recommendations in Canada's Food Guide of 2 to 3 servings per day for children up to 11 years of age and 3 to 4 servings per day for adolescents (Health and Welfare Canada, 1977). The mean daily vitamin A intake from dairy products excluding the school supplement was approximately equal to that provided by one serving for most groups of children. The mean vitamin A contribution from the school food supplement ranged from the amount in less than one half of a serving to the amount in approximately one serving. Thus the mean intakes of dairy products from all sources, including the contribution from the school supplement, ranged from approximately one to two servings in all communities. In Brochet the children in both grades had greater vitamin A intakes from dairy products excluding the school supplement than did their counterparts in the other communities. Possibly the distribution of the supplement to all children resulted in a greater appreciation for the use of milk and milk products at home.

In addition to the evidence for a risk of vitamin A deficiency as suggested by the dietary data, children in this study were found to have low intakes of calcium (Sevenhuysen et al., 1984). Dilling and coworkers (1978) have also found marginal vitamin D intakes among Manitoba Indian children. Dairy products (fortified with vitamin D) are good sources of all three of these nutrients, thus an increase in their intake could improve nutrient intake.

Ellestad-Sayed and coworkers (1980) found that few Manitoba Indian school children were milk intolerant. Among 67 children who were fed 245 ml of milk, 5 (7%) were lactose malabsorbers based on the breath H_2 test, and 2 (3%) were milk intolerant, which was defined as lactose malabsorption plus clinical signs (diarrhea, cramps, flatulence, and/or meteorism). The breath H_2 test is a measure of the increase in the amount of hydrogen excreted in the breath after the ingestion of lactose. For individuals who are lactose malabsorbers, the lactose which remains in the intestines is fermented by bacteria and hydrogen is released (Thiele, 1976). If the lactose malabsorption is severe enough clinical signs appear. The researchers in this study suggested that the low prevalence of milk intolerance among Manitoba Indian school children should not preclude the promotion of milk programs in the schools. However, they suggested that diluted (1:1) evaporated whole milk be used rather than reconstituted skim milk powder, because higher mean H_2

excretions were found among a group of children fed the latter.

Among Moose Lake, Cormorant Lake, Barrows Junction and Brochet no significant differences in vitamin A intakes were found. Yet the relative contribution of the food groups varied, illustrating that similar levels of intake can result from different dietary choices. The implication for nutrition interventions is that the objectives related to changing food intakes may vary among communities, depending on the existing and potential food sources as well as the preferences of the residents.

School Food Supplement Effect

No significant differences were found in the intake variables between those children who received the school supplement and those who did not. A number of factors may have contributed to this finding. The school supplement may have displaced foods which would have otherwise been provided at home. An assessment of the vitamin A contribution from dairy products suggested that this may have been the case in Moose Lake.

In Cormorant Lake and Barrows Junction, where the school supplement was not offered on the day of the interview, the vitamin A intake from dairy products for the grade 4 children was equal to that provided by slightly more than one serving of milk (126 and 120 RE, respectively). The mean intake from dairy products other than the school supplement was similar for the grade 4 children in Crane River (126 RE), suggesting that the school supplement contribution in Crane River was in addition to foods given at home. In contrast, the mean intake from dairy products other than the school supplement was lower for grade 4 children in Moose Lake (82 RE), suggesting that the school supplement may have displaced foods which would have otherwise been given at home. Since the mean vitamin A intakes from dairy products were similar for the grade 6 children in all four communities (94 to 103 RE), it does not seem that the lower intake by the grade 4 children in Moose Lake was due to a community difference in the consumption of dairy products. The school supplement may have had a greater tendency to displace other foods in Moose Lake because it was more varied and substantial than in Crane River; some children in Moose Lake reported receiving both milk and cheese on the day of the interview, whereas children in Crane River received milk only.

The school supplement was consumed by all grade 4 children in Moose Lake, whereas one third of the grade 4 children in Crane River did not consume the supplement. This may have been related to the time of distribution and thus the amount of supervision in the communities. In Moose Lake the supplement was offered during class time in the mid-morning, whereas it was offered at lunch time in Crane River. By comparison, the level of participation in Brochet, where the supplement was distributed in the morning before classes began, was between those found in Moose Lake and Crane River. Presumably by mid-morning all children who were attending school would have arrived, and supervision would have been greater than at lunch time when some children went home for lunch.

Another factor which may have contributed to the lack of significant differences in the intake variables between those children who were offered the school supplement and those who were not is the fact that the grade 4 children in Cormorant Lake and Barrows Junction regularly received the school supplement on other days. This may have affected their choices on the day of the interview, when they did not receive it.

Madden and coworkers (1976) found that 24-hour recalls tended to underestimate differences between groups of individuals because there was a tendency for respondents to overestimate small amounts and underestimate large amounts of food eaten. This may have contributed to the lack of significant differences in estimates of vitamin A intake.

Finally, the contribution of vitamin A from the school supplement may not have been large enough in relation to the total intakes and possible differences may have been obscured by the high variability in the total vitamin A intakes.

No significant school food supplement effect was found for the serum vitamin A level either. This would be expected since no children had serum levels indicative of a risk of vitamin A deficiency.

The findings for the dark adaptation test variables were counterintuitive. The grade 4 children (those who regularly received the school supplement) took significantly longer to perform the test than the grade 6 children (those who did not regularly receive the supplement). The age difference between the two groups of children may have had an influence on the test times.

Solomons and coworkers (1982) studied the dark adaptation ability of two groups of healthy children using the rapid dark adaptation test. Due to procedural differences between the two groups, the data are not strictly comparable, however, the geometric mean test time for a group of 4 and 5 year old children in Baltimore was greater than that for a group of 5 to 12 year old children in Guatemala. Rapid dark adaptation test times have also been previously shown to vary with age among healthy adults (Vinton and Russell, 1981).

Possibly the older children in the present study were better able to comprehend the task.

Relationships Between Variables

No significant relationships were found between any of the dietary, biochemical, or clinical indicators of vitamin A status. Correlations between serum vitamin A levels and dietary intakes in other studies have been reported to be poor (ICNND, 1963; and Owen et al., 1974). The homeostatic mechanism of serum vitamin A regulation, whereby available liver stores of vitamin A are mobilized to maintain serum levels at physiologically adequate levels, means that the serum levels do not necessarily reflect recent intakes of vitamin A (Sauberlich et al., 1974a). In the present study, there was no evidence of vitamin A deficiency as measured by serum levels, thus a correlation between serum vitamin A levels and dietary intakes would not be expected. In addition, since vitamin A is not evenly distributed in the food supply, the high day-to-day variability in intakes could mask a correlation.

Although Solomons and coworkers (1982) found significant correlations between rapid dark adaptation test times and vitamin A intakes with both linear and log models among healthy Baltimore children, it was not unexpected to find no relationships in the present study. The serum vitamin A levels and dark adaptation test scores were not indicative of a risk of vitamin A deficiency among the children. In addition, both the rapid dark adaptation test scores and the dietary intakes were highly variable.

The reason for the tendency for a positive (counterintuitive) relationship between the dark adaptation test variables and the natural logs of the intake variables at the lower values is not clear. A positive correlation between the rapid dark adaptation test time and the amount of supplemental vitamin A voluntarily taken by college students has also been reported (Solomons, 1982, personal communication).

The lack of evidence of a risk of vitamin A deficiency as measured by the clinical and biochemical variables would explain the lack of relationship between these variables. Vinton and Russell (1981) found a significant negative correlation between rapid dark adaptation test times and the logs of serum vitamin A levels. However, their sample included persons with serum vitamin A levels as low as 15 μg/100 ml. No one in the present study had a level below 40 μg/100 ml.

CONCLUSIONS

General Vitamin A Status

No evidence of vitamin A deficiency was suggested by the biochemical and clinical indicators of vitamin A status, however, the dietary data suggested that some children may have been at risk of vitamin A deficiency. The diets of the children, especially those in Crane River, could have been improved at the time of the study. Store-bought foods provided the greatest amount of vitamin A in the diets of the children in all communities. Moose was another source of vitamin A which provided substantial amounts of vitamin A to the diets of the children in all communities, except Crane River. In addition, locally produced foods contributed to the vitamin A intakes in Cormorant Lake and Barrows Junction. The data suggested that the dietary intakes of vitamin A were related to the vitamin A concentrations of the foods chosen, rather than the total amount of food consumed.

The dairy product consumption of the children in all communities was low. In addition, there was dietary evidence of low vitamin A and calcium intakes among the children (Sevenhuysen et al., 1984), and others have found low vitamin D intakes among Manitoba Indian children (Dilling et al., 1978). Dairy products are good sources of all of these nutrients, thus an increase in their consumption could improve nutrient intake.

Analysis of food group contributions to the vitamin A intakes of the children showed that similar intakes were met by different food choices in several communities. Thus objectives to change food intakes may vary among communities. For example, changes in the access to foods with high vitamin A concentrations, such as volume supply and price policy changes, and changes in the public awareness of available foods and their nutritional benefits may influence vitamin A intakes, but differences among the communities suggested that any one intervention may not be equally effective in all communities. Studies at other times of the year would help to clarify the degree of risk of vitamin A deficiency and thus the amount of emphasis needed on nutrition intervention.

Community Differences

The mean values for the dietary intake variables were lowest for the Crane River children, with the vitamin A density of their diets being significantly different from those in all other communities, and the values for the other three intake variables being significantly different from

Moose Lake and/or Brochet. No significant differences were found among any of the other communities for any of the intake variables. There did not seem to be any simple relationship between the degree of isolation of the communities and the intakes of vitamin A, and the data showed that food choices varied among all the communites.

There were no differences found among the communities for either the serum vitamin A level or the dark adaptation test variables. This was in keeping with the finding that no children were found to be at risk of vitamin A deficiency as measured by these variables.

School Food Supplement Effect

No significant differences were found in the vitamin A intake variables or the serum vitamin A levels between those children who received the school supplement and those who did not, whereas the findings for the dark adaptation test variables were counterintuitive. The finding that the grade 4 children (those who regularly received the school supplement) took longer to perform the dark adaptation test than the grade 6 children (those who did not regularly receive the supplement) suggests that age is a confounding variable which needs to be controlled for when using the rapid dark adaptation test. The lack of a significant school supplement effect on the serum vitamin A levels was not unexpected since the serum levels did not indicate any risk of vitamin A deficiency among the children.

Several methodological factors may have influenced the lack of a significant school supplement effect on the intake variables: 1) the fact that the grade 4 children in Cormorant Lake and Barrows Junction regularly received the school supplement on other days may have affected their choices on the day of the interview when they did not receive it; 2) twenty-four hour recalls have been found to underestimate differences between groups of individuals (Madden et al., 1976); and 3) the high variability in the total vitamin A intakes may have masked any possible differences.

There are other factors which may have contributed to the finding of no supplement effect which may be possible to change: 1) some of the children who were offered the supplement did not consume it; and 2) the school supplement may have displaced foods which would otherwise have been given at home. The data suggested that the distribution time which was associated with the greatest participation in the school supplement program was mid-morning during class time. It could be postulated that a nutrition education program for both children and members of the wider community, aimed at creating awareness of the appropriate use of milk products at home in addition to at school, may support the impact of a school food supplement on nutritional health.

Relationships Between Variables

No significant relationships were found between any of the dietary, biochemical, or clinical indicators of vitamin A status. This was not unexpected. There was no evidence of vitamin A deficiency among the children as measured by the serum vitamin A levels or the dark adaptation test scores. In addition the variability in the vitamin A intakes and the dark adaptation test scores could mask possible relationships.

The reason for the tendency for a positive (counterintuitive) relationship between the dark adaptation test variables and the natural logs of the intake variables at the lower values is not clear. Further research into the sources of variability in the rapid dark adaptation test is needed so that the test can be standardized for use with different population groups.

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APPENDIX 1

CHILD CONSENT FORM

The purpose of the nutrition study for the Frontier School has been explained to me. I agree that the survey team can take 5 ml (~2 tsp.) of blood from my child named below and also ask my child questions on the foods he/she eats, investigate eye function through a dark adaptation test, take height and weight.

I understand that participation is entirely voluntary and that if I wish I will receive all results of tests and analysis of food eaten that relate to my child. I also understand that either myself or my child refusing to participate will in no way influence the service and support I or any member of my family can expect to receive from the Frontier Schools or any other public service.

All information collected by the survey team will be kept confidential. Only those involved in interviewing, and their immediate supervisors, will have access to individual answers. None of this information will be released to others without permission from the Director, Nutrition and Health Program, if it can be identified.

Name: ______________________________

Name of parent/guardian: ______________________________

Signature: ______________________________

Date: ______________________________

Address: ______________________________

____

____

Instructions for interviewers on the verbal explanation of the survey to be given to the subjects.

Women

Good ______________. My name is ______________. Have you heard about the food survey the school is doing?....I am working with the Frontier School on its survey. We are interested in learning what foods people use and what foods are available.

I would like to ask you some questions about the food you ate yesterday as well as foods you may have eaten at other times. This will take about an hour. All that you tell me will be between you and me. No one at the school or in the rest of the community will know what you alone told me. Your answers will be put together with those of other people who help us out. They will then be sent to the university where they will be analyzed. The results will be reported as a group.

We would also like to measure your height and weight and ask you a few questions about your family so that the information we gather will be more meaningful to us.

Let the person respond. Answer any questions she may have. Some other things which may aid in discussion are to relate that: 1) if she is interested she can receive advice on the nutritional value of the foods she eats (Note: if she is interested, then get information on where we should send the results), and 2) the study is to try and improve Frontier School's program which gives out food supplements (and advice on good eating habits).

Additional points for data collection with children

We are interested in whether the children are getting enough vitamin A, vitamin C, and iron from the food they eat. For this we ask that you allow a small amount of blood (5 millilitres or about 2 teaspoons) to be taken from (child's name)'s arm.

We would also like to do something called a dark adaptation test. (Child's name) would be asked to divide a pile of white, red and blue poker chips into three separate piles. This would be done in a room with little light after there has been a bright light on. It's like going from outside on a bright sunny day into a building where it's not so bright. How fast the children can tell the difference between the coloured poker chips depends on how much vitamin A they are getting from the food they eat.

The questions about the foods (child's name) eats and the measuring of his/her height and weight plus the dark adaptation test will be done during this week. The blood will be taken (time) when our nurse can come.

A point to aid discussion is that if the adult gives consent, the child will still not be forced to give blood if he/she really objects.

(Note: The wider evaluation of the Nutrition and Health Program of the Frontier School Division included information from women.)

APPENDIX 2

Figure 3.

24 Hour Recall Form

page of pages

Subject no. _____

TIME	WORK AREA - FOODS CONSUMED			
I	FOOD ITEM II	DESCRIPTION III	SOURCE IV	AMOUNT V

Figure 4.

Respondent Information Form

Code ____________

Date ________________

Area of Study ____________

Sex: M_____ F _____

Place of Interview ___________

Yesterday was: M T W Th F S Sn

* * * * * * * * * * * *

Vitamin or mineral supplement Yes _____ No _____

Type/Brand ____

Amount ____

Recalled food intake was typical Yes _____ No _____

If not, why ____

* * * * * * * * * * * *

Height __________ __________ __________ cm

Weight __________ __________ __________ kg

Clothing worn during weighing ________________________________

Age __________

Advisor ____________________

24 Hour Recall

Purpose and general instructions for interviewers

The purpose of the 24 hour recall is to determine as exactly as possible the food and beverage intake of an individual over a period of one whole day, or 24 hours. The interviewer will guide the respondent through the previous 24 hours. She will begin with the last major meal period (breakfast, dinner or supper) before the time of the interview and work backwards until six meal periods (including three snack periods) have been recorded.

To begin, an explanation of specifically what is involved in a 24 hour recall will be necessary even though it has been mentioned when explaining the study, eg. "I would like you to tell me everything you ate and drank during the last day. Please tell me everything whether it was just a bite, a cup of coffee, a candy, or a beer. We will start with (breakfast time, dinner time, supper time) today and work back to yesterday (morning, afternoon, evening)." At this time it will also be necessary to explain what the models are, and if in the home, to ask if there is a place to set them out.

After the explanation, begin the process of probing for the information needed, eg. "OK, let's start. Did you have anything to eat or drink at (breakfast time, dinner time, supper time) today?" If yes, eg. "Would you please tell me what you had...Did you have anything else to eat or drink...We've talked about (summary of foods mentioned so far) ...Can you think of anything else you ate or drank at that time?"

Write down all information in the appropriate columns on the form (meal period name and approximate time(s) in column I, food items plus their descriptions in columns II and III, and amounts in column V). When satisfied that all information has been gathered for the first meal period, draw a line across the form. Continue in the same way for each of the five meal periods remaining.

After all meal periods have been discussed, return and ask about sources, first explaining what you mean, eg. "Now I would like to know where the food you have told me about came from. In other words, was it bought from a store, and if so, was it a store here in the community or one outside. If it wasn't bought at a store, was it from a garden here or was it from the wild?" Write the source information in column IV.

Tips and things to remember

1. Information that is needed about foods and beverages
   a. Amounts as exact as possible--suggest models to the respondent for use
   b. Types of foods--some egs.
      i. milk--canned, canned diluted, 2%, skim, whole, powdered
      ii. juice--sweetened or unsweetened, "real" or crystals

iii. ice cream--get type and brand if known
--for bars write down name, eg. revel, creamsicle, etc.
iv. cocoa--brand and if made with milk or water
v. cookies & cakes--if bought, then brand; if homemade, then kind
vi. pies--kind, one or two crusts
vii. bread--brown or white (Note: remember children may think white bread toasted is brown)

c. Contents of combination foods (stews, pizza, casseroles, soups, salads, etc.)
i. if bought, then write down brand, eg. Puritan Irish Stew, Kraft macaroni dinner
ii. if homemade, get a list of the major ingredients and their proportions. If can't get proportions then record by using such words as mostly meat, some potatoes and few carrots. (Note: for broth-type soups, the amount of broth vs. solids is also important)

d. How foods are prepared
i. boiled, baked, fried, etc. (Note: if fried, ask type of fat as butter and margarine have more vit. A than lard or shortening)
ii. whether foods (eg. soups, bannock, cocoa) are made with milk or water. (Note: if milk, ask type).

e. If anything is added to the major food mentioned--some egs.
i. spreads to bread
ii. icing to cake
iii. gravy to meats or vegetables
iv. spreads to vegetables
v. batters to fried meats
vi. dressings to salads
vii. sugar and "cream" to beverages
(Note: remember that people often say cream but it may have been milk or coffeemate. Also, if it was cream, there are a number of types--half and half, whipping)

2. <u>Recording information on the form</u>

a. Amounts
i. when have more than one of the same thing (eg. 3 cookies) then put that number before the model letter
ii. when talking about a line on the model, put that number after the model letter (models with lines are glasses, bowls, and the plate with circles)
iii. when amount is half way between two mounds, write the two letters with a hyphen between them.
iv. when amount is half way between two lines on a model, write number as a half
some egs.
--2 pancakes size at circle 9 of plate (2PL9)
--1 glass of juice up to line 3 on glass B (B3)
--corn between the two smallest mounds (Z-S)
--1 bowl of soup between lines 2 and 3 on bowl D (D2½)

b. Sources
   i. store
      a. in community--StC
      b. outside community--St plus place, eg. St The Pas
   ii. school--Sc
   iii. restaurant/arena/community centre--R
   iv. gathered berries, wild meat (self or gift)--W
   v. garden (self)--G
   vi. farmer (vegetables, eggs, meat, milk, etc.)--F
   vii. other--write it out
      (Note: if there are any uncertainties, write out all the information the person gives)

c. If find out no butter or margarine added to vegetables, no snack eaten, etc., then record nothing.

d. If there are more than one snack eaten during a snack period, then in column I there would be recorded only one name of a meal period, but more than one approximate time.
   eg. evening snack 7:30
                     9:00

3. <u>Probing is very important</u>

a. To help people remember what they ate--some egs.
   i. have people think about what they were doing during the day--did they visit a friend's place or go to the store, etc.
   ii. if people talk of one snack during a snack period, remember to ask if there were any others during that period (people tend to forget snacks--one type which women may forget especially is nibbling while cooking)
   iii. summarize what the person has already mentioned when aiding recall for each meal.

b. To get the detailed information needed
   i. people won't know that they need to tell exact amounts, types, whether anything is added to the major foods, cooking methods, etc. Therefore probing questions will be needed.

4. <u>Ways to ask questions</u>

a. When talking about meal periods ask, "Did you have anything to eat or drink at (breakfast time, dinner time, supper time)?" rather than, "What did you have at (breakfast, dinner, supper)?" The second question implies that they did eat something at the time specified and they may not have. This is especially important when talking about breakfast time and dinner time as they are the two meals most often skipped.

b. If a person describes a breakfast-type meal during questioning about dinner time, record foods as described. It is then important to avoid embarrassing the person in case she got up late and thus had a late breakfast. Therefore continue by first asking a question like, "Did you have anything earlier during the morning?" rather than asking about morning snack and breakfast time.

c. When clarifying about types or amounts of foods, additions to major foods, approximate times, etc., use questions that don't suggest a specific answer. For example, use, "What kind of milk was that?" rather than, "Was that canned milk?" Questions such as "Was that canned or fresh or...?" can also be used. (Note: by leaving an "or" at the end, it is left open enough to include the one the person used).

APPENDIX 3

Table 25. Food model descriptions.

Model and Alphabetical Identity	Volume or Area	
Cups		
S (3 3/8" rim, 2 5/8" high)	Division 1	3.00 fl oz (89 ml)
	Division 2	6.00 fl oz (177 ml)
A (3 3/8" rim, 3 3/8" high)	Division 1	4.50 fl oz (133 ml)
	Division 2	9.00 fl oz (266 ml)
Glasses		
Q (2 ¼" rim, 3 3/8" high)	Division 1	1.25 fl oz (37 ml)
	Division 2	2.50 fl oz (74 ml)
	Division 3	3.75 fl oz (111 ml)
	Division 4	5.00 fl oz (148 ml)
V (2 5/8" rim, 3 3/4" high)	Division 1	1.75 fl oz (52 ml)
	Division 2	3.50 fl oz (104 ml)
	Division 3	5.25 fl oz (156 ml)
	Division 4	7.00 fl oz (208 ml)
B (3" rim, 5 ½" high)	Division 1	3.00 fl oz (89 ml)
	Division 2	6.00 fl oz (177 ml)
	Division 3	9.00 fl oz (266 ml)
	Division 4	12.00 fl oz (355 ml)
Bowls		
D (5" rim, 1 ¼" high)	Division 1	2.00 fl oz (59 ml)
	Division 2	4.00 fl oz (118 ml)
	Division 3	6.00 fl oz (177 ml)
F (5 3/4" rim, 1 5/8" high)	Division 1	6.00 fl oz (177 ml)
	Division 2	10.00 fl oz (296 ml)
	Division 3	12.00 fl oz (355 ml)
Mounds		
Z (3" base, 1" high)		2.00 fl oz (59 ml)
P (4" base, 1 ½" high)		6.00 fl oz (177 ml)
L (5" base, 1 3/4" high)		10.00 fl oz (296 ml)
C (6" base, 1 3/4" high)		16.00 fl oz (474 ml)
Spoons		
E (level "teaspoon")		0.17 fl oz (5 ml)
M (rounded "teaspoon")		0.30 fl oz (9 ml)
H (half level "dessertspoon")		0.17 fl oz (5 ml)
J (level "dessertspoon")		0.30 fl oz (9 ml)
CC (rounded "dessertspoon")		0.51 fl oz (15 ml)
SS (rounded "tablespoon")		0.78 fl oz (23 ml)

Table 25. (continued)

Model and Alphabetical Identity	Volume or Area
Milk Container	
T (individual container as used in restaurants)	0.51 fl oz (15 ml)
Retail Meat Cuts	
K	7.0 in^2 (45 cm^2)
N	11.0 in^2 (71 cm^2)
Y	16.0 in^2 (103 cm^2)
R	32.0 in^2 (206 cm^2)
Squares	
E (1 3/4" side)	3.0 in^2 (20 cm^2)
M (2 ¼" side)	5.0 in^2 (33 cm^2)
K (2 5/8" side)	7.0 in^2 (45 cm^2)
N (3 5/16" side)	11.0 in^2 (71 cm^2)
G (3 5/8" side)	13.0 in^2 (85 cm^2)
Y (4" side)	16.0 in^2 (103 cm^2)
Plate With Concentric Circles	
PL1 (1 3/4" diameter)	2.4 in^2 (16 cm^2)
PL2 (2 ¼" diameter)	4.0 in^2 (26 cm^2)
PL3 (2 3/4" diameter)	5.9 in^2 (38 cm^2)
PL4 (3 ¼" diameter)	8.3 in^2 (53 cm^2)
PL5 (3 3/4" diameter)	11.0 in^2 (71 cm^2)
PL6 (4 ¼" diameter)	14.2 in^2 (91 cm^2)
PL7 (4 3/4" diameter)	17.7 in^2 (114 cm^2)
PL8 (5 ¼" diameter)	21.6 in^2 (140 cm^2)
PL9 (5 3/4" diameter)	26.0 in^2 (167 cm^2)
9 3/8" Plate With Wedges	
PN	3.6 in^2 (23 cm^2)
PR	5.1 in^2 (33 cm^2)
PE (1/8 of plate)	8.6 in^2 (56 cm^2)
PS (1/6 of plate)	11.5 in^2 (74 cm^2)
PQ (¼ of plate)	17.3 in^2 (111 cm^2)
PT (1/3 of plate)	23.0 in^2 (148 cm^2)

APPENDIX 4

Foods modified or added to the database.

1. Bannock (Code 4111)

The fat content of bannock was modified to be 8.5 g/100 g of bannock rather than 0.6 g/100 g. The amount of energy was modified accordingly to be 299 kcal/100 g rather than 228 kcal/100 g.

Determination of fat content was made using the mean amounts in the following recipe which was obtained from a Nutrition and Health Advisor from the Frontier School Division:

2 or 3 Tbsp. Baking Powder
3 or 4 Tbsp. Lard
2 to 4 Cups Flour
1 Pinch Salt

Two calculations were made, one assuming 1 Cup of whole milk was used, and one assuming only water was used. The amounts of fat from these two calculations were averaged.

2. "Cooked" moose (Code 6002)

Values for nutrients were calculated by using amounts in raw moose as analyzed by Mann and coworkers (1962). These values were multiplied by "cooked to raw" ratios which were calculated by averaging values for 17 choice cuts of separable lean beef in U.S. Handbook No. 8. (Watt and Merrill, 1963).

Nutrient	Composition of 100 g of raw moose	"cooked to raw" ratio	Composition of 100 g of "cooked" moose
Water (g)	72.4	0.84	61.0
Energy (kcal)	113	1.35	153
Protein (g)	25.5	1.41	36.0
Fat (g)	1.1	1.26	1.4
Carbohydrate (g)	0	--	0
Ash (g)	1.0	1.13	1.1
Calcium (mg)	16	1.04	17
Vitamin A (RE)	300	1.00[a]	300
Thiamin (mg)	0.021	0.76	0.016
Riboflavin (mg)	0.365	1.21	0.440

[a]The ratio calculated for vitamin A by the above defined procedure was 1.09, but it was decided to use 1.00 as 15 of the 17 ratios were 1.00 with the other two being 2.00 and 1.50. There is little vitamin A in beef (3 to 9 RE/100 g).

3. Roasted venison (Code 6004)

   Values were those reported by Paul and Southgate (1978).

4. Steakettes (Code 6006)

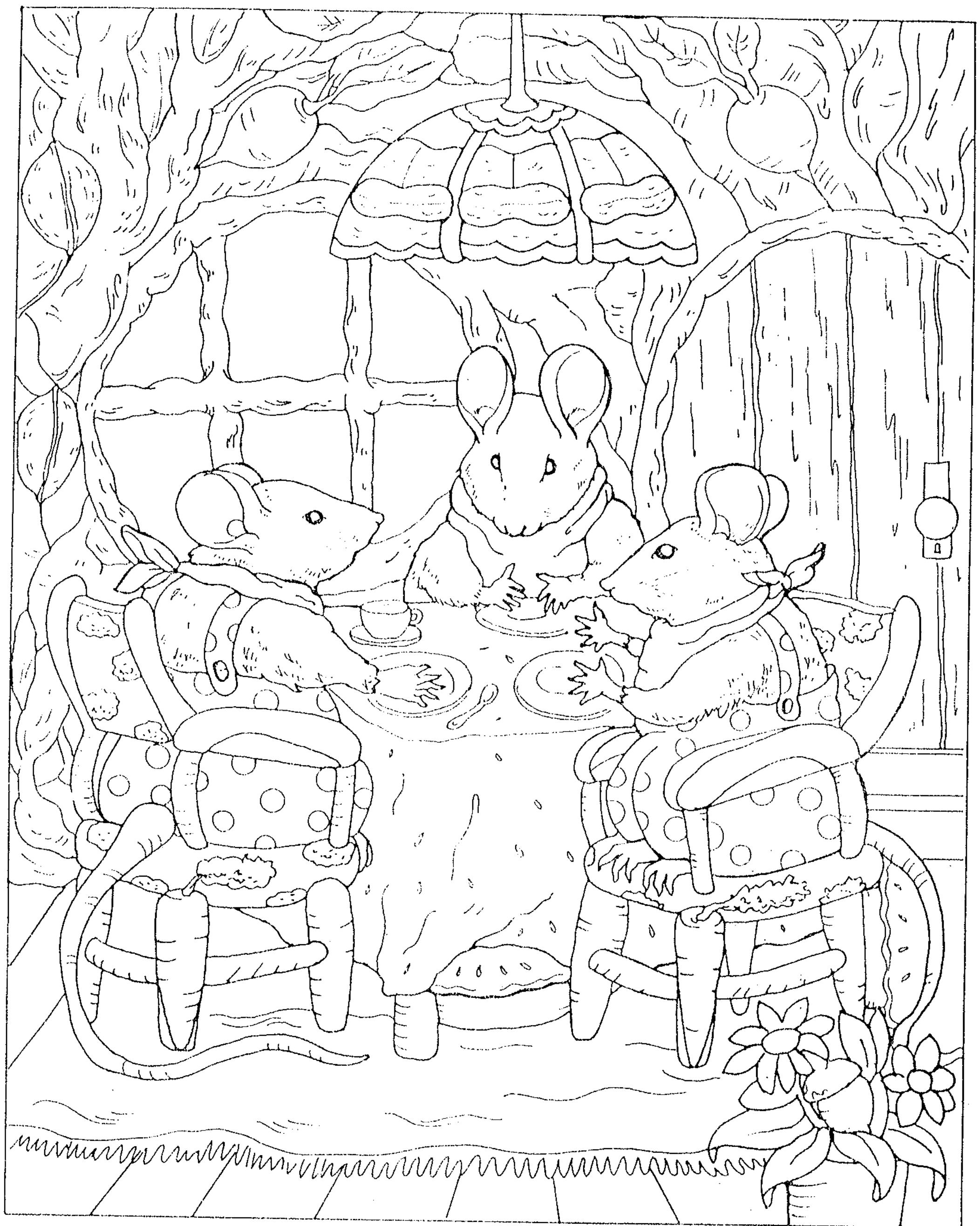
   Values used were those reported for "beefburgers" by Paul and Southgate (1978).

5. Potatoes fried from raw in butter (Code 6008)

   Values used were the same as those for potatoes fried from raw (Code 1790) in U.S. Handbook No. 8 (Watt and Merrill, 1963) with 139.59 RE of vitamin A/100 g of potato added. There are 14.2 g of fat/100 g of fried potatoes (Code 1790) and 0.1 g of fat/100 g of raw potatoes, thus it was assumed that for potatoes fried in butter the amount of vitamin A/100 g of potatoes would be equivalent to that in 14.1 g of butter.

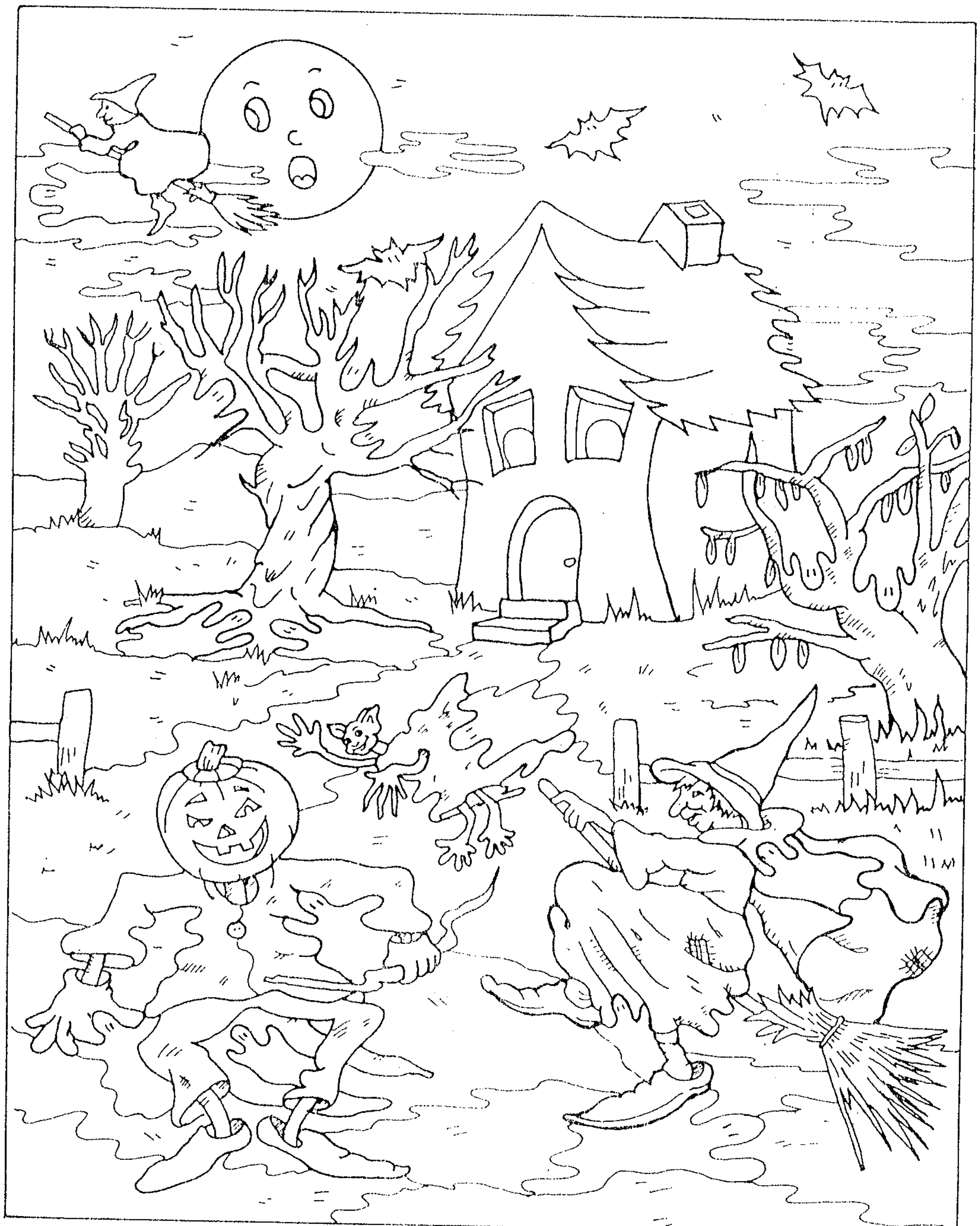
APPENDIX 5

Figure 5. Line drawing number 1.
(Pomaska, 1980)



The 3 mice are somewhat upset. They have come home for a supper party only to find all their good food has disappeared! But if they look very carefully, they will find 3 peanuts, 2 pies, 2 cheeses, 2 carrots, 2 beets, 2 walnuts and 1 acorn.

Figure 6. Line drawing number 2.
(Pomaska, 1980)



It is Halloween night and all the witches, ghouls and jack-o'-lanterns have come out to celebrate. The ghosts too are flying about, but true to their nature, have vanished into the night. Can you make them appear again? There are 16 ghosts in the picture.

Figure 7. Line drawing number 3.
(Pomaska, 1980)

The mischievous March wind has caught up many different items in its breezy travels. Can you find all the things that are whirling and tumbling about him? There are 2 dresses, 2 socks, 1 shoe, 1 cap, 1 umbrella, 1 spoon, 1 broom and 1 sailboat.

APPENDIX 6

Figure 8.

Dark Adaptation Test Recording Form

Code ________ Date ______________

Time of day ____________ Area of Study ______

Glasses prescribed Yes ____ No ____

Glasses worn Yes ____ No ____

Comments:

Test Times

	White Time	Blue Time
Trial 1	________	________
Trial 2	________	________
Trial 3	________	________

Initials _____

APPENDIX 7

T-test and Bonferroni multiple comparisons B used to test for the community differences in the intake variables.

T-test

$$t_1^* = \frac{\hat{L}_1 - 0}{s_{\hat{L}_1}}$$

where t_1^* was the calculated t value;

$\hat{L}_1$ was the contrast defined on page 64;

and $s_{\hat{L}_1}$ was the standard deviation for the contrast calculated using the following equation:

$$s_{\hat{L}_1} = \sqrt{\frac{MSE}{4}\left(\frac{1}{n(gr4A)} + \frac{1}{n(gr6A)} + \frac{1}{n(gr4B)} + \frac{1}{n(gr6B)}\right)}$$

where MSE was the mean square for error from the one-way ANOVA for the ten community by grade groupings;

n(gr4A) and n(gr6A) were the sample sizes for grades 4 and 6 in one community;

and n(gr4B) and n(gr6B) were the sample sizes for grades 4 and 6 in another community.

Bonferroni multiple comparisons B for two-sided tests (Neter and Wasserman, 1974)

$$B = t_{\alpha/2s,\, n_T - r}$$

where t was the tabular t value;

α was the level of significance (0.05);

s was the number of contrasts in the family for each intake variable (10);

n_T was the total sample size (133);

and r was the number of community by grade groupings used in the ANOVA (10).

If $t_1^* > B$, then it was concluded that there was a significant difference between the two communities compared.

T-test and tabular t used to test for the school supplement effect on the intake variables.

T-test

$$t_2^* = \frac{\hat{L}_2 - 0}{S_{\hat{L}_2}}$$

where t_2^* was the calculated t value;

$\hat{L}_2$ was the contrast defined on page 65;

and $S_{\hat{L}_2}$ was the standard deviation for the contrast calculated using the following equation:

$$S_{\hat{L}_2} = \sqrt{\frac{MSE}{4}\left(\frac{1}{n(gr4CR)} + \frac{1}{n(gr6CR)} + \frac{1}{n(gr4ML)} + \cdots + \frac{1}{n(gr6BA)}\right)}$$

where MSE was the mean square for error from the one-way ANOVA for the eight community by grade groupings, excluding data from Brochet;

and n(gr4CR), n(gr6CR), n(gr4ML), etc. were the sample sizes for the eight community by grade groupings.

Tabular t for one-sided tests

$$t = t_{\alpha, n_T - r}$$

where t was the tabular t value;

α was the level of significance (0.05);

n_T was the total sample size (104);

and r was the number of community by grade groupings used in the ANOVA (8).

If $t_2^* > t$, then it was concluded that there was a significant school supplement effect.

APPENDIX 8

Figure 9. Interviewer histograms of vitamin A intake residuals from a one-way ANOVA of the ten community by grade groupings.

Residual Midpoints (RE)	Interviewer 1	Interviewer 2	Interviewer 3	Interviewer 4	Residual Midpoints (RE)
1950					1950
1800		F			1800
1650				G	1650
1500					1500
1350					1350
1200		DD			1200
1050	C		H		1050
900	C				900
750	AF		I	JJ	750
600		E	J	H	600
450	A	CE	I	IJ	450
300	B	AC	GI	GH	300
150	ABDEEEF	BBBDE	HIJJ	GH	150
0	DDEF	AABBBEEF	HIII	GIIIJ	0
-150	ABBBBCD	BDDE	GJ	GGGH	-150
-300	AAAAABCCEF	CEEFF	GGHHJ	GHHH	-300
-450	DFF	CCFF	GHIIJJ	GIJJJ	-450
-600	DD	CDE		I	-600
-750					-750
-900					-900

Legend:
A = Crane River, grade 4
B = Crane River, grade 6
C = Moose Lake, grade 4
D = Moose Lake, grade 6
E = Cormorant Lake, grade 4
F = Cormorant Lake, grade 6
G = Barrows Junction, grade 4
H = Barrows Junction, grade 6
I = Brochet, grade 4
J = Brochet, grade 6

Figure 10. Interviewer histograms of energy intake residuals from a one-way ANOVA of the ten community by grade groupings.

Residual Midpoints (kcal)	Interviewer 1	Interviewer 2	Interviewer 3	Interviewer 4	Residual Midpoints (kcal)
2400	E				2400
2200					2200
2000		BB			2000
1800					1800
1600		A			1600
1400	E			I	1400
1200		C		J	1200
1000	AF	EF	GHIJ	I	1000
800				G	800
600	DD	DF	J	GHHIJ	600
400	AACD	ACC	GJ		400
200	BBBEFF	B	HHI	GGGJ	200
0	BBCCD	CDDF	I	H	0
-200	ABDDEF	ACDEEF	GHHHIIJ	GHIJJ	-200
-400	AACD	DEEFF	IIJ	GGHIJ	-400
-600	AEFFF	BDEE	GIIJ	GH	-600
-800	A	E	G	H	-800
-1000	ABC	BBC	J	J	-1000
-1200		E		I	-1200
-1400		B			-1400

Legend:
A = Crane River, grade 4
B = Crane River, grade 6
C = Moose Lake, grade 4
D = Moose Lake, grade 6
E = Cormorant Lake, grade 4
F = Cormorant Lake, grade 6
G = Barrows Junction, grade 4
H = Barrows Junction, grade 6
I = Brochet, grade 4
J = Brochet, grade 6

APPENDIX 9

Table 26. DAT[a] times in seconds for children with glasses prescribed but not worn for the community by grade by vitamin A concentrate groupings; $\bar{x}$, (n).

		Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	No Vitamin Concentrate	248 (3)	209 (4)	241 (1)	296 (1)	196 (1)
	Vitamin Concentrate	244 (1)	--- (0)	299 (1)	--- (0)	--- (0)
Grade 6	No Vitamin Concentrate	198 (2)	244 (1)	221 (1)	250 (1)	237 (3)
	Vitamin Concentrate	--- (0)	116 (1)	244 (5)	300 (1)	424 (1)

[a] DAT time for one individual was the average time of the two recorded trials.

Table 27. DAT[a] times in seconds for children who did not need vision correction or wore their glasses for the community by grade by vitamin A concentrate groupings; $\bar{x}$, (n).

		Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	No Vitamin Concentrate	276 (9)	269 (8)	231 (8)	214 (8)	267 (6)
	Vitamin Concentrate	248 (1)	219 (2)	196 (5)	296 (4)	259 (8)
Grade 6	No Vitamin Concentrate	202 (11)	197 (9)	183 (7)	212 (12)	249 (8)
	Vitamin Concentrate	181 (1)	200 (1)	--- (0)	215 (1)	204 (1)

[a]DAT time for one individual was the average time of the two recorded trials.

Table 28. BestDAT[a] times in seconds for children with glasses prescribed but not worn for the community by grade by vitamin A concentrate groupings; $\bar{x}$, (n).

		Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	No Vitamin Concentrate	180 (3)	199 (4)	233 (1)	245 (1)	163 (1)
	Vitamin Concentrate	207 (1)	--- (0)	296 (1)	--- (0)	--- (0)
Grade 6	No Vitamin Concentrate	180 (2)	154 (1)	217 (1)	224 (1)	194 (3)
	Vitamin Concentrate	--- (0)	100 (1)	194 (5)	293 (1)	369 (1)

[a]BestDAT time for one individual was the shortest time of the two recorded trials.

Table 29. BestDAT[a] times in seconds for children who did not need vision correction or wore their glasses for the community by grade by vitamin A concentrate groupings; $\bar{x}$, (n).

		Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	No Vitamin Concentrate	232 (9)	229 (8)	211 (8)	177 (8)	234 (6)
	Vitamin Concentrate	236 (1)	214 (2)	177 (5)	262 (4)	230 (8)
Grade 6	No Vitamin Concentrate	173 (11)	164 (9)	134 (7)	192 (12)	212 (8)
	Vitamin Concentrate	171 (1)	177 (1)	--- (0)	189 (1)	168 (1)

[a]BestDAT time for one individual was the shortest time of the two recorded trials.

APPENDIX 10

Table 30. Rapid dark adaptation test times in seconds which have been reported in the literature.

Researchers	Sample Description: Location	Subject Health	Age	Sex	n	Arithmetic Mean ± SEM	Geometric Mean[a]	Comments on procedure
Vinton and Russell, 1981	Baltimore, MD.	Healthy	20-39 yr	M&F	16	182 ± 15		-used matte finish Munsell colour discs
		Healthy	40-60 yr	M&F	16	265 ± 12[b]		-used average of 2 recorded trials[d] after an initial trial
		Vit A Deficient	40-60 yr	M&F	14	458 ± 29[c]		-light adaptation for 60 sec at 50 cm from a standard x-ray view box
Kim and Solomons, 1982	Cambridge, MA.	Healthy	$\bar{x}$=23 yr	M	20	143 ± 13	136	-used matte finish plastic discs -used average of 2 best attempts among 3 recorded trials after an initial trial
		Colour Blind	$\bar{x}$=20 yr	M	20	154 ± 18[e]	143	
	Guatemala	Healthy	adults	M&F	100		148	-light adaptation for 120 sec at 45 cm from a standard x-ray view box
Solomons et al., 1982	Baltimore, MD.	Healthy	4-5 yr	M&F	16		171	-used matte finish Munsell colour discs -used a single valid trial after an initial trial -light adaptation for 60 sec at 50 cm from a standard x-ray view box
	Guatemala	Healthy	5-12 yr	M&F	27		144	-used matte finish plastic discs -used average of 2 best attempts among 3 recorded trials after an initial trial -light adaptation for 120 sec at 45 cm from a standard x-ray view box

Table 30. (continued)

Researchers	Sample Description					Arithmetic	Geometric[a]	Comments on procedure
	Location	Subject Health	Age	Sex	n	Mean ± SEM	Mean	
Sevenhuysen, 1984	Winnipeg, Man.	Healthy	19-30 yr	F	5	278		-used reflective finish plastic discs -used mean of 4 consecutive trials recorded after an initial trial -light adaptation for 60 sec at reading distance from a 2' by 3' matte off white paper illuminated with a 200 W tungsten bulb
	Winnipeg, Man.	Healthy	19-30 yr	F	5	155		-used matte finish Munsell colour discs -used mean of 4 consecutive trials recorded after an initial trial -light adaptation for 60 sec at reading distance from a 2' by 3' matte off white paper illuminated with a 200 W tungsten bulb

[a] geometric mean = $(x_1 \cdot x_2 \cdot x_3 \ldots x_n)^{1/n}$, and is always less than the arithmetic mean (Alder and Roessler, 1968)

[b] significantly different from healthy adults, 20-39 yr ($p<0.001$)

[c] significantly different from healthy adults, 40-60 yr ($p<0.001$)

[d] no significant difference between the two recorded trials

[e] no significant difference from healthy men

APPENDIX 11

Table 31. Vitamin A intake, excluding the contributions from moose and the school supplement, expressed in retinol equivalents for the community by grade groupings; $\bar{x}$ ± SEM, (n).

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	375±98 (12)	515±154 (11)	571±80 (14)	654±105 (14)	693±81 (15)
Grade 6	405±45 (14)	381±139 (13)	663±188 (12)	539±102 (14)	702±112 (14)

Table 32. Vitamin A intake, excluding the contributions from moose and the school supplement, expressed as a percentage of the Canadian recommendation for the community by grade groupings; $\bar{x}$ ± SEM, (n).

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	51±14 (12)	70±21 (11)	81±12 (14)	87±13 (14)	90±11 (15)
Grade 6	49±6 (14)	46±17 (13)	83±23 (12)	67±12 (14)	87±14 (14)

Table 33. Vitamin A intake, excluding the contributions from moose and the school supplement, expressed as a percentage of the weight recommendation for the community by grade groupings; $\bar{x} \pm$ SEM, (n).

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	64±20 (12)	77±22 (11)	97±13 (14)	102±13 (14)	109±14 (15)
Grade 6	60±6 (14)	51±19 (13)	100±28 (12)	77±14 (14)	104±19 (14)

Table 34. Vitamin A density, excluding the vitamin A and energy from moose and the school supplement, expressed in RE/100 kcal for the community by grade groupings; $\bar{x} \pm$ SEM, (n).

	Crane River	Moose Lake	Cormorant Lake	Barrows Junction	Brochet
Grade 4	18±4 (12)	33±9 (11)	44±6 (14)	37±8 (14)	33±4 (15)
Grade 6	21±4 (14)	20±6 (13)	35±8 (12)	34±6 (14)	35±5 (14)

One-way ANOVA and t-tests (see pages 62 and 64, formula $\hat{L}_1$) indicated that Crane River had significantly lower values than Cormorant Lake ($p<0.03$).

APPENDIX 12

Table 35. Results of tests for relationships between serum vitamin A and the four intake variables.

Relationship	Group	n	Coefficient of Correlation (r)	Coefficient of Determination (r^2)	p
Serum vitamin A in μg/100 ml vs Vitamin A intake in RE	NSNC[a]	14	0.0857	0.0073	0.771
	NSC[b]	8	0.1326	0.0176	0.754
	OTHERNC[c]	68	0.1152	0.0133	0.350
	OTHERC[d]	20	0.0617	0.0038	0.796
	ALL[e]	110	0.1131	0.0128	0.239
Serum vitamin A in μg/100 ml vs Vitamin A intake expressed as a % of the Canadian recommendation	NSNC	14	0.1816	0.0330	0.534
	NSC	8	0.1326	0.0176	0.754
	OTHERNC	68	0.1316	0.0173	0.285
	OTHERC	20	0.0694	0.0048	0.771
	ALL	110	0.1200	0.0144	0.212
Serum vitamin A in μg/100 ml vs Vitamin A intake expressed as a % of the weight recommendation	NSNC	14	0.2626	0.0689	0.365
	NSC	8	0.0736	0.0054	0.862
	OTHERNC	68	0.0960	0.0092	0.436
	OTHERC	20	0.1162	0.0135	0.626
	ALL	110	0.0831	0.0069	0.388
Serum vitamin A in μg/100 ml vs Vitamin A density in RE/100 kcal	NSNC	14	0.2844	0.0809	0.324
	NSC	8	0.1576	0.0248	0.709
	OTHERNC	68	0.1405	0.0197	0.253
	OTHERC	20	0.0366	0.0013	0.878
	ALL	110	0.1014	0.0103	0.292

[a]Data for children who did not receive their regular school food supplement and who did not take a vitamin A concentrate.

[b]Data for children who did not receive their regular school food supplement and who took a vitamin A concentrate.

[c]Data for all other children who did not take a vitamin A concentrate.

[d]Data for all other children who took a vitamin A concentrate.

[e]Data for all children.

Table 36. Results of tests for relationships between DAT[a] time and the four intake variables.

Relationship	Group	n	Coefficient of Correlation (r)	Coefficient of Determination (r^2)	p
DAT time in sec vs Vitamin A intake in RE	GR4NS[b]	27	-0.2123	0.0451	0.288
	GR4S[c]	38	0.2607	0.0680	0.114
	GRADE6[d]	64	-0.0421	0.0018	0.741
	ALL[e]	129	0.0489	0.0024	0.582
DAT time in sec vs Vitamin A intake expressed as a % of the Canadian recommendation	GR4NS	27	-0.1831	0.0335	0.360
	GR4S	38	0.2550	0.0650	0.122
	GRADE6	64	-0.0368	0.0014	0.773
	ALL	129	0.0734	0.0054	0.408
DAT time in sec vs Vitamin A intake expressed as a % of the weight recommendation	GR4NS	27	-0.1469	0.0216	0.465
	GR4S	38	0.3257	0.1061	0.046
	GRADE6	64	-0.0529	0.0028	0.678
	ALL	129	0.0985	0.0097	0.267
DAT time in sec vs Vitamin A density in RE/100 kcal	GR4NS	27	-0.2590	0.0671	0.192
	GR4S	38	0.1308	0.0171	0.434
	GRADE6	64	0.0408	0.0017	0.749
	ALL	129	0.0103	0.0001	0.908

[a]DAT time for one individual was the average time of the two recorded trials.

[b]Data for grade 4 children who did not receive their regular school food supplement.

[c]Data for grade 4 children who received their regular school food supplement.

[d]Data for all grade 6 children.

[e]Data for all children.

Table 37. Results of tests for relationships between bestDAT[a] time and the four intake variables.

Relationship	Group	n	Coefficient of Correlation (r)	Coefficient of Determination (r^2)	p
BestDAT time in sec vs Vitamin A intake in RE	GR4NS[b]	27	-0.2827	0.0799	0.153
	GR4S[c]	38	0.3427	0.1175	0.035
	GRADE6[d]	64	-0.0459	0.0021	0.719
	ALL[e]	129	0.0597	0.0036	0.501
BestDAT time in sec vs Vitamin A intake expressed as a % of the Canadian recommendation	GR4NS	27	-0.2433	0.0592	0.222
	GR4S	38	0.3219	0.1036	0.049
	GRADE6	64	-0.0445	0.0020	0.727
	ALL	129	0.0843	0.0071	0.342
BestDAT time in sec vs Vitamin A intake expressed as a % of the weight recommendation	GR4NS	27	-0.2051	0.0421	0.305
	GR4S	38	0.3838	0.1473	0.017
	GRADE6	64	-0.0547	0.0030	0.668
	ALL	129	0.1123	0.0126	0.205
BestDAT time in sec vs Vitamin A density in RE/100 kcal	GR4NS	27	-0.2714	0.0736	0.171
	GR4S	38	0.2047	0.0419	0.218
	GRADE6	64	0.0452	0.0020	0.723
	ALL	129	0.0321	0.0010	0.718

[a]BestDAT time for one individual was the shortest time of the two recorded trials.

[b]Data for grade 4 children who did not receive their regular school food supplement.

[c]Data for grade 4 children who received their regular school food supplement.

[d]Data for all grade 6 children.

[e]Data for all children.

Table 38. Results of tests for relationships between DAT[a] time and the natural logs of the four intake variables.

Relationship	Group	n	Coefficient of Correlation (r)	Coefficient of Determination (r^2)	p
DAT time in sec vs Ln (Vitamin A intake in RE)	GR4NS[b]	27	-0.1329	0.0177	0.509
	GR4S[c]	38	0.2617	0.0685	0.112
	GRADE6[d]	64	0.0575	0.0033	0.652
	ALL[e]	129	0.1166	0.0136	0.188
DAT time in sec vs Ln (Vitamin A intake expressed as a % of the Canadian recommendation)	GR4NS	27	-0.0913	0.0083	0.650
	GR4S	38	0.2654	0.0704	0.107
	GRADE6	64	0.0633	0.0040	0.619
	ALL	129	0.1358	0.0184	0.125
DAT time in sec vs Ln (Vitamin A intake expressed as a % of the weight recommendation)	GR4NS	27	-0.0375	0.0014	0.853
	GR4S	38	0.2760	0.0762	0.094
	GRADE6	64	0.0345	0.0012	0.787
	ALL	129	0.1353	0.0183	0.126
DAT time in sec vs Ln (Vitamin A density in RE/100 kcal)	GR4NS	27	-0.2316	0.0536	0.245
	GR4S	38	0.1349	0.0182	0.420
	GRADE6	64	0.1237	0.0153	0.330
	ALL	129	0.0773	0.0060	0.384

[a] DAT time for one individual was the average time of the two recorded trials.

[b] Data for grade 4 children who did not receive their regular school food supplement.

[c] Data for grade 4 children who received their regular school food supplement.

[d] Data for all grade 6 children.

[e] Data for all children.

Table 39. Results of tests for relationships between bestDAT[a] time and the natural logs of the four intake variables.

Relationship	Group	n	Coefficient of Correlation (r)	Coefficient of Determination (r^2)	p
BestDAT time in sec vs Ln (Vitamin A intake in RE)	GR4NS[b]	27	-0.1976	0.0390	0.323
	GR4S[c]	38	0.3798	0.1442	0.019
	GRADE6[d]	64	0.0782	0.0061	0.539
	ALL[e]	129	0.1583	0.0251	0.073
BestDAT time in sec vs Ln (Vitamin A intake expressed as a % of the Canadian recommendation)	GR4NS	27	-0.1483	0.0220	0.460
	GR4S	38	0.3776	0.1426	0.019
	GRADE6	64	0.0819	0.0067	0.520
	ALL	129	0.1787	0.0319	0.043
BestDAT time in sec vs Ln (Vitamin A intake expressed as a % of the weight recommendation)	GR4NS	27	-0.0976	0.0095	0.628
	GR4S	38	0.3856	0.1487	0.017
	GRADE6	64	0.0610	0.0037	0.632
	ALL	129	0.1835	0.0337	0.037
BestDAT time in sec vs Ln (Vitamin A density in RE/100 kcal)	GR4NS	27	-0.2411	0.0581	0.226
	GR4S	38	0.2560	0.0655	0.121
	GRADE6	64	0.1487	0.0221	0.241
	ALL	129	0.1271	0.0161	0.151

[a]BestDAT time for one individual was the shortest time of the two recorded trials.

[b]Data for grade 4 children who did not receive their regular school food supplement.

[c]Data for grade 4 children who received their regular school food supplement.

[d]Data for all grade 6 children.

[e]Data for all children.

Table 40. Results of tests for relationships between DAT[a] time and serum vitamin A plus its natural log.

Relationship	Group	n	Coefficient of Correlation (r)	Coefficient of Determination (r^2)	p
DAT time in sec vs Serum vitamin A in µg/100 ml	GR4NC[b]	37	0.2253	0.0507	0.180
	GR4C[c]	20	-0.1474	0.0217	0.535
	GR6NC[d]	46	0.2035	0.0414	0.175
	GR6C[e]	10	0.1529	0.0234	0.673
	ALL[f]	113	0.1836	0.0337	0.052
DAT time in sec vs Ln (Serum vitamin A in µg/100 ml)	GR4NC	37	0.2212	0.0489	0.188
	GR4C	20	-0.1487	0.0221	0.532
	GR6NC	46	0.1917	0.0367	0.202
	GR6C	10	0.1294	0.0168	0.722
	ALL	113	0.1813	0.0329	0.055

[a]DAT time for one individual was the average time of the two recorded trials.

[b]Data for grade 4 children who did not take a vitamin A concentrate.

[c]Data for grade 4 children who took a vitamin A concentrate.

[d]Data for grade 6 children who did not take a vitamin A concentrate.

[e]Data for grade 6 children who took a vitamin A concentrate.

[f]Data for all children.

Table 41. Results of tests for relationships between bestDAT[a] time and serum vitamin A plus its natural log.

Relationship	Group	n	Coefficient of Correlation (r)	Coefficient of Determination (r^2)	p
BestDAT time in sec vs Serum vitamin A in µg/100 ml	GR4NC[b]	37	0.1659	0.0275	0.326
	GR4C[c]	20	0.0055	0.0000	0.982
	GR6NC[d]	46	0.1579	0.0249	0.295
	GR6C[e]	10	0.2427	0.0589	0.499
	ALL[f]	113	0.1749	0.0306	0.064
BestDAT time in sec vs Ln (Serum vitamin A in µg/100 ml)	GR4NC	37	0.1697	0.0288	0.315
	GR4C	20	0.0115	0.0001	0.962
	GR6NC	46	0.1524	0.0232	0.312
	GR6C	10	0.2209	0.0488	0.540
	ALL	113	0.1767	0.0312	0.061

[a]BestDAT time for one individual was the shortest time of the two recorded trials.

[b]Data for grade 4 children who did not take a vitamin A concentrate.

[c]Data for grade 4 children who took a vitamin A concentrate.

[d]Data for grade 6 children who did not take a vitamin A concentrate.

[e]Data for grade 6 children who took a vitamin A concentrate.

[f]Data for all children.

APPENDIX 13

Table 42. Vitamin A densities of locally produced foods expressed in RE/100 kcal.

		Child	Food	Overall Vitamin A Density
Crane River	Grade 4	105	potatoes	0
		111	tomatoes	61
		112	potatoes	0
		114	potatoes	0
	Grade 6	135	potatoes	0
		137	strawberries	16
Cormorant Lake	Grade 4	302	potatoes	0
		303	carrots (raw)	2619
		309	summer squash	305
	Grade 6	337	corn	44
		339	carrots (boiled)	3387
Barrows Junction	Grade 4	405	whole milk	74
		406	potatoes, carrots, and onions	287
		407	butter, potatoes, carrots, and onions	609
		409	potatoes	0
		411	whole milk	74
	Grade 6	431	pork chop	0

APPENDIX 14

Table 43. Contribution of food groups to the daily vitamin A intake in retinol equivalents for each grade and all children in each community; $\bar{x}$, (n).

Food Group	Crane River			Moose Lake			Cormorant Lake			Barrows Junction			Brochet		
	Gr4	Gr6	All	Gr4	Gr6	All	Gr4	Gr6	All	Gr4	Gr6	All	Gr4	Gr6	All
Dairy products															
-total excl. school supp.	126	94	109	82	100	92	126	103	116	120	95	107	177	126	153
-school supp. contribution	38	0	17	97	0	44	0	0	0	0	0	0	52	89	70
Wild game and fish	0	0	0	426	304	360	120	112	117	124	67	96	122	115	119
Eggs	0	114	61	47	27	36	125	73	101	76	113	93	290	149	222
Domestic meat, poultry, and fish	2	9	5	4	14	9	8	15	10	0	21	10	23	33	27
Vegetables including dried legumes	11	8	9	139	124	131	82	287	176	154	7	80	8	87	46
Soups	117	10	60	47	36	41	58	12	37	167	109	138	24	60	42
Fats and oils	88	144	119	101	54	76	123	148	134	113	125	119	126	203	163
Fruits and fruit products	19	5	11	6	5	5	24	12	19	20	14	18	15	30	22
Grain products	7	4	6	4	11	8	1	9	5	4	12	8	0	4	2
Misc. products incl. sugars, mixtures, nuts, and seeds	5	17	11	111	12	58	26	6	17	2	44	24	31	11	21
TOTAL	413	405	408	1064	687	860	693	777	732	780	607	693	868	907	887
	(12)	(14)	(26)	(11)	(13)	(24)	(14)	(12)	(26)	(14)	(14)	(28)	(15)	(14)	(29)