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Dietary supplement use and its impact on nutritional adequacy for British Columbia and Manitoba First Nations adults living on reserve

par

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Ce mémoire intitulé:

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Présentée par:
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a été évaluée par un jury composé des personnes suivantes :

Malek Batal, président-rapporteur
Olivier Receveur, directeur de recherche
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Résumé

Contexte: L'utilisation de suppléments alimentaires est répandue chez les populations américaines et canadiennes en général, mais on en sait peu sur la consommation de suppléments alimentaires dans la population autochtone canadienne.

Objectif: L'objectif général de cette étude est de prendre en compte l'utilisation de suppléments alimentaires dans l'évaluation nutritionnelle des apports alimentaires des adultes des Premières nations vivant dans les réserves en Colombie-Britannique et Manitoba.

Conception: Les données ont été recueillies par l'étude 'First Nations Food, Nutrition, and Environment Study' de 1103 (Colombie-Britannique) et 706 (Manitoba) adultes des Premières Nations âgés de 19 à 70 ans. L'étude a utilisé un rappel alimentaire des dernières 24 heures (avec un deuxième rappel pour un sous-échantillon) pour évaluer la diète alimentaire. L'utilisation de suppléments alimentaires et des antiacides ont été recueillis par un questionnaire de fréquence. En utilisant le logiciel SIDE pour tenir compte des variations intra-individuelles dans la prise alimentaire et la technique du bootstrap pour obtenir des estimations représentatives des différentes régions, l'utilisation de suppléments de la vitamine A, D, C et de calcium ont été intégrées aux estimations de la consommation alimentaire.

Résultats: Environ 30% des adultes des Premières Nations de la Colombie-Britannique et seulement 13,2% des adultes des Premières Nations du Manitoba âgés entre 19-70 ans vivant dans les réserves ont déclaré utiliser au moins un supplément alimentaire durant les 30 jours précédents. Lors de l'examen des nutriments d'intérêt, un plus faible pourcentage de la population en a fait usage, de 14,8 à 18,5% en Colombie-Britannique et de 4,9 à 8% de la population du Manitoba. La prévalence de l'usage de tout supplément alimentaire était plus élevée chez les femmes que chez les hommes dans tous les groupes d'âge et augmente avec l'âge dans les deux sexes. La plus forte prévalence d'un apport insuffisant provenant de la nourriture a été observée pour la vitamine D et le calcium en Colombie-Britannique et Manitoba, variant de 75 à 100%, et de la vitamine A dans le Manitoba (73-96%). Après avoir examiné l'utilisation de suppléments alimentaires, plus des trois quarts des participants n'ont toujours pas réussi à répondre au besoin moyen estimatif pour ces nutriments. La vitamine C est l'oligo-élément avec le plus faible pourcentage sous le besoin moyen estimatif (avec au sans suppléments) pour la Colombie-Britannique et le Manitoba.

Conclusion: La majorité des adultes des Premières nations de la Colombie-Britannique et du Manitoba, même après prise en compte de l'utilisation de suppléments alimentaires, avaient des apports en vitamines A, D et des apports de calcium sous les niveaux recommandés. L'utilisation de compléments alimentaires n'a pas contribué de façon significative à l'apport total en nutriments sélectionnés sauf pour la vitamine C dans certains groupes d'âge.

Mots-clés : autochtones canadiens, utilisation de suppléments alimentaires, nutrition adéquate.

Abstract

Background: The use of dietary supplements is prevalent among general US and Canadian populations; however, little is known about consumption of nutritional supplements among the Canadian Aboriginal population.

Objective: The overall goal of this study was to integrate supplement use into dietary intake for the assessment of nutritional adequacy in British Columbia and Manitoba First Nation adults living on reserve.

Design: Data were collected by the First Nations Food, Nutrition, and Environment Study from 1103 BC and 706 MA First Nation adults aged 19-70 years old. The study used 24-hour food recalls (with a second recall in a subsample) to assess diet. Dietary supplement and antacid use were collected by a frequency questionnaire. Using SIDE software to account for intra-individual variation in food intake and bootstrap weights to obtain regionally representative estimates, vitamin A, D, C, and calcium supplement use were incorporated to food intake estimates.

Results: About 30% of British Columbia and only 13.2% of Manitoba First Nation people aged 19-70 y living on reserve reported use of at least one dietary supplement within the prior 30 days. When considering the nutrients of interest, a smaller percentage of the populations took them varying from nutrient to nutrient from 14.8 to 18.5% in British Columbia and from 4.9 to 8% in Manitoba population. The prevalence of use of any dietary supplement was higher among women than men in all age groups and increased with age in both genders. The highest prevalence of inadequate intakes from food alone was observed for vitamin D and calcium in both British Columbia and Manitoba varying from 75 to 100%, and for vitamin A in Manitoba (73-96%). After considering the use of dietary supplements, more than three fourth of participants still failed to meet the EAR for these nutrients. Vitamin C was the micronutrient with the lowest percentage of BC and Manitoba participants bellow the EAR with or without supplements consumption.

Keywords : Canadian Aboriginal population, dietary supplement use, nutritional adequacy.

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List of Abbreviations

AI: Adequate Intake

BC: British Columbia

BCNS: British Columbia Nutrition Survey

CaMos: Canadian Multicentre Osteoporosis Study

CCHS: Canadian Community Health Survey

CSFII: Continuing Survey of Food Intake by Individuals

DFE: Dietary folate equivalents

DIN: Drug Identification Number

DRI: Dietary Reference Intake

EAR: Estimated Average Requirement

FDA: Food and Drug Administration

FFQ: food frequency questionnaire

FHC: Food Habits of Canadians

FNFNES: First Nations Food Nutrition and Environment Study

ISU: Iowa State University

MA: Manitoba

MVMM: multivitamin-multimineral supplements

NCI: National Cancer Institute

NCIS: National Health Interview Survey

NHANES: National Health and Nutrition Examination Survey

NHP: Natural Health Product

RBC: red blood cell

UL: Upper Level

USDA: United States Department of Agriculture

WCBA: women of childbearing age

SE: standard error

SIDE: Software for Intake Distribution Estimation

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Chapter 1: Introduction

The importance of diet and nutrition in promoting and maintaining good health throughout the entire life is well recognised. However, rapid changes in diets and lifestyles that have occurred with industrialisation and economic development resulted in shifting dietary patterns, particularly increased consumption of high fat, energy-dense, low in micronutrients, and unrefined carbohydrates diets (1). An even greater nutritional transition was observed among Canadian Aboriginal populations, particularly First Nations living on reserve, whose diet primarily relied on nutritionally dense traditional foods. Contemporary Aboriginal diets have replaced to varying extents traditional foods with market foods, many of which are of poor nutritional quality (e.g. candy, soft drinks, condiments, snack foods, fast food). These changes in food choices may explain, at least in part, the development of nutrition-related health problems such as diabetes, obesity, and inadequacy of intake of several nutrients (2, 3, 4, 5).

Of particular interest are inadequate intakes of vitamin A, C, D, and calcium often reported among Canadian Aboriginal people (6, 7, 8, 9, 10, 11).

Nutrition and health professionals recommend consuming varieties of foods as the optimal foundation for a nutritionally adequate diet with consumption of dietary supplements advisable for certain individuals. For example (12,13,14,15), calcium supplementation may be recommended for women after menopause because of hormonal imbalance and increased needs in calcium; vitamin D containing supplements are advised for older people as vitamin D production in skin is becoming less effective with age; vegetarians may be suggested to take iron, vitamin B12, and calcium supplements since they omit meat and dairy products. Supplement use has therefore the possibility of filling some gaps in intake but may also increase the potential risk of adverse effects from excessive intakes (16, 17).

Some Canadian surveys have been assessing the adequacy of nutrient intakes from diet as well as the use of dietary supplements and their impact on total nutrient intakes among the general populations (18,19,20,21,22,23,24,25). Regarding Aboriginal populations, several studies were performed but included only food and beverage intakes. The information on dietary supplement use was collected by some of these studies, but was not included in the analysis.

The First Nations Food Nutrition and Environment Study (FNFNES) collected the information about the diet of British Columbia and Manitoba First Nation people living on reserve with the goal to assess nutritional status and estimate potential health risks (26). However, the analyses to date (27,28) did not include supplement consumption.

Therefore, the overall goal of this study is to integrate supplements use into dietary intake for the assessment of nutritional adequacy in British Columbia and Manitoba First Nations living on reserves. Our specific objectives are to calculate total usual intake of selected nutrients (vitamins A, C, D and calcium) for adult First Nations based on food/beverages and supplements consumption; and evaluate the impact of dietary supplements use on nutrient adequacy.

Chapter 2: Literature review

2.1. Introduction.

The consumption of dietary supplements is widespread and has been increasing among the general population of North America (29, 30, 31, 32, 33). Dietary supplements of all varieties, including single-ingredient products and various combinations of vitamins, minerals, botanicals, and other constituents, have been widely marketed. The most common reasons for taking dietary supplements are for the improvement of nutrition, compensation for nutrients missing in the food supply, decreasing susceptibility to (or severity) of disease, or increasing energy or the improvement of performance (22, 34, 35). Sales of dietary supplements have increased significantly in the past decades (Table 2.3). The Nutrition Business Journal reported that supplement sales grew from $8.6 to $14.9 billion dollars between 1994 and 1999, with growth in sales of all categories of supplements; from 2000, the sales of dietary supplements have been increasing consistently by 4,4% each year reaching $28.1 billion in sales in 2010 with vitamin and mineral supplements being the third most common category of medications used in the United States (36, 37, 38).

This literature review presents the overall use of multivitamin/multimineral supplements among U.S. and Canadian population, the contribution of dietary supplements to total dietary intake, and methods utilized to combine nutrient intake from food and supplements. Also, it briefly describes the health status of Canadian Aboriginal population and prevalence of supplement use among Aboriginal people.

2.2. Dietary supplement use in the United States.

Use of multivitamin-multimineral (MVMM) supplements can contribute substantially to total nutrient intakes. Supplements have the potential to fill dietary gaps but, at the same time, may increase intakes above upper levels. Thus, intake from supplements must be included along with intakes from conventional and fortified foods and beverages when assessing nutritional adequacies of individuals and population groups. The National Health and Nutrition Examination Survey (NHANES) has been used to monitor the use of dietary supplements in the United States since the 1970s. The NHANES has collected data on dietary supplement usage from nationally representative sample of the civilian, non-institutionalized US population.

In NHANES I (1971-74), the prevalence of dietary supplement daily use was 23% of the population aged 1–74 (39). Particularly, dietary supplements were used regularly by 26% of females and 19% of males, with total usage increasing with age—from about 20% in young adults to almost 30% in people over 60. Detailed data on vitamin supplement use for nine specific vitamins and minerals were presented.

In NHANES II, conducted from 1976 to 1980, adult supplement use was about 35% (40). However, there were some differences between the two surveys in terms of the analyzed populations. Block et al. (39) examined only regular supplement users 1–74 years of age, while Koplan et al. (40) looked at regular (21.4%) and irregular users (13.5%) 18–74 years of age, who also had completed 24-hour dietary recalls. If irregular users were included in NHANES I analyses, the prevalence of supplement use would be 33 % (39). Also, Koplan et al. excluded pregnant and lactating females from their analyses. Nevertheless, in both surveys greater supplement use was associated with female gender (versus male), older age, more education, non-Hispanic white ethnicity, higher income, and former smoking.

In NHANES III (1988-1994), about 40 % of the population 2 months of age and older reported taking vitamin, mineral, or other types of dietary supplements in the past month (34,35). These estimates ranged from 24 to 55 percent in the various age/sex groups and include pregnant and lactating women. Regular (defined as daily) supplement users were not distinguished from occasional users. The major users of supplements were children 1–5 years of age, with the prevalence of 42 to 51%. The supplement use prevalence among youth 6–19 was lower and ranged between 24-35%. Surprisingly, about two thirds of adult supplement users (67%) took only one supplement, primarily multivitamins (34). The leading supplements taken were multivitamin/multiminerals (MVMM) (22%), multivitamins plus vitamin C (15%), vitamin C as a single vitamin (13%), other dietary supplements such as herbal and botanical supplements (7%), and vitamin E as a single vitamin (6%) (41). As in numerous other surveys, usage was more prevalent in women than in men and in people with somewhat more education and income (34).

In addition to the NHANES surveys, other national surveys have examined vitamin and mineral supplement use (42,43,44). In a 1980 Food and Drug Administration (FDA) national telephone interview survey, approximately 4 in 10 adults 16 years old and over, excluding pregnant/lactating women, used vitamin and mineral supplements on a daily basis (44). This survey represented the proportion who took any vitamin at least once in the prior 14 days. Of those users, 52.4% consumed only one supplement (44). In 1987, the National Centre for Health Statistics (NCHS) as a part of the National Health Interview Survey (NHIS) collected information to produce estimates of vitamin and mineral supplement users and the composition and quantities of specific nutrients consumed. According to this report, about 36% of adults 18 years old and over, excluding pregnant and lactating women, and 43% of young children 2 to 6 years of age residing in the United States used non-prescription vitamin and mineral supplement products (45). Multivitamins were the most common type of used vitamin and mineral product. When Subar and Block (42) approximated the same reference period that Stewart et al. (44) used in the FDA survey, that is, the previous 14 days, they found that 38.7 percent of adults 18 years and over in the 1987 NHIS survey were taking vitamin and mineral supplements (42). Of the total population, 51.1% stated that they had consumed some supplement in the past year; however, only 23.1% took at least one supplement on a daily year-round basis. Bender et al. (46) reported a significant decline in supplement use among adults (42 vs. 38 percent, respectively) between the 1980 FDA survey and the 1987 NHIS survey. According to the

Slesinski et al. report (43), there was a 4.9% decline in the total population reporting use of any vitamin or mineral supplements (51 vs. 46.1%, respectively) between the 1987 and 1992 NHIS surveys when the results were expressed in terms of any use in the past year. In the 1992 NHIS the proportion of the population reporting regular, daily use of any of the specified supplements was 23.7% that is nearly the same as that reported in the first NHANES (39). Thus, although it is impossible to make direct comparisons across all of these surveys, the results tend to suggest that the prevalence of supplement use among adults on a national level has remained fairly stable between 1970s and 1990s. The next National Health Interview Survey (NHIS) was conducted in 2000 when, according to findings by Millen et al (2004), the prevalence of reported use of any vitamin/mineral supplements any time in the past year did not change significantly between 1987 (51.2%) and 2000 (51.0%). However, the percentage of respondents reporting daily use was greater in 2000 (33.9%) than in either 1992 (23.0%) or 1987 (23.2%) (47).

The Continuing Survey of Food Intake by Individuals (CSFII), the national survey of dietary intake conducted by the US department of Agriculture, found that the percentage of adult men and women age 20 and older who reported any supplement use in the 1989–91 CSFII was 32.3% and 46.9%, respectively, compared with 41.9% and 55.8% in the 1994–96 CSFII , respectively (48). In the 1994 Continuing Survey of Food Intakes by Individuals (CSFII), approximately one-third of the 423 adolescents surveyed reported using supplements, with 16% using them on daily basis. Most of the supplement users (65.5%) reported using MVMM formulations (49). Looker et al (50) reported that 10% to 14% of adolescents used supplements daily when 16% to 17% used supplements irregularly. However, Dickinson et al (51) reported 9% to 15% of adolescents used supplements daily and 15% less frequently. Another cross-sectional observational study, the Third Child and Adolescent Trial for Cardiovascular Health, analyzed one thousand five hundred thirty-two students in grade 8. The report showed that about 17.6% of the students reported using vitamin-mineral supplements (52). Supplement use was higher among Caucasians than among the other ethnic groups while no significant differences were noted by gender (52).

More recent studies indicate similar or somewhat higher usage levels. A random survey of noninstitutionalized U.S. adults (The Slone Survey) examined the use of all medications, including prescription and over-the-counter drugs, vitamins and minerals, and herbal preparations/natural supplements between 1998 and 1999 (53). The survey found that about 35% of adults used vitamin or mineral supplements in the week before the survey. Like other surveys, it found that usage was higher among women than men and increased with age in both groups. The report also notes that about 14 % of the population used herbal or other natural supplements. The published report also indicated that these products were used for nonspecific reasons such as "health" (53).

From 1999, NHANES became a continuous survey, with data collected annually and released to the public in 2-year cycles. Based on the 1999-2000 National Health and Nutrition Examination Survey, 52% of adults (57% of women and 47% of men) aged 20 years and older reported taking at least one dietary supplement in the past month (29). Forty-seven percent of adult supplement users took just one supplement. The most commonly used supplements were multivitamin/mineral supplements (35%), vitamin C (12%), and vitamin E (13%). Ten percent reported using calcium supplements, which increased to 25% when calcium containing antacids were included. Adults who used supplements are more likely to be women, older adults, non-Hispanic whites, people with more than a high-school education, people who rate their health as excellent/very good, who are more physically active, former smokers, and under- and normal-weight people (29,31).

Comparison of these data with those from previous NHANES surveys, which used similar methodology, suggests that supplement use increased (31). Data from children prevalence of supplement use from the 1999-2002 NHANES suggested that almost 32% of children and adolescents reported supplementing their diets with some type of vitamins and minerals (54) while the secondary analysis of 1999-2004 NHANES reported 34% of supplement use in children and adolescents (55). Picciano et al (54) reported the lowest use among infants younger than 1 year (12%), and teenagers 14 to 18 years old (26%). The highest supplement use is among 4 to 8 year-old children (almost 49%). The type of supplement most commonly used was multivitamins and multiminerals (18.3%). The primary supplemental nutrients consumed were ascorbic acid (28.6%), retinol (25.8%), vitamin D (25.6%), calcium (21.1%), and iron (19.3%). Factors associated with greater use among children included younger age, more healthful diets, greater food security, families with higher incomes and education, greater physical activity, and better access to health care (54).

The next NHANES survey was conducted from 2003 to 2006. According to Bailey et al (32), dietary supplement use was reported by 49% of all Americans aged 1 year and older (44% of males and 53% of females). Among adults, aged 20 y and over, about 54% reported dietary supplement use that indicates a slight increase from 1999-2000 NHANES survey (29). The majority of users (79%) reported taking one supplement every day within last 30 days. Between 28 and 30% of the U.S. population took supplements containing one or more of the following vitamins: B-6, B-12, C, A and E; 17% took supplements containing vitamin K (32). Vitamin B-6, B-12 and C use was higher among adults >51 y and children 4-8 years old when vitamin A, E and K – among adults >71 y and children <8 years old. The lowest prevalence of supplement use was among adolescents 14-18 y (26%) and the highest – among individuals >71 y (71%). Multivitamin-multimineral use was the most frequently reported among both adults and children (33%).

According to the Bailey et al (56) analysis, 34.5% of US population used dietary supplements that contained folic acid. From those, the higher use was associated with female gender and older age (51-70-year-olds, with 47% of men and 53% of women reporting use in this age group). Also, higher intake was more prevalent among non-Hispanic whites (39%) than among non-Hispanic blacks (19%) and Mexican Americans (18%) (56). Among children aged 1-13 years old, 28% reported use of products containing folic acid during the previous 30 days (58). Use of dietary supplements contained calcium was reported by 43% of all US population and almost by 70% of older male and female (58). Thirty seven percent of the population reported use of supplement containing vitamin D (2005-2006). Fewer males than females reported use, 33% and 40%, respectively whereas individuals >71 y had the highest reported use of both genders (58).

The most recent NHANES study was conducted in 2007-2008. Based on the data, Kennedy et al (2013) suggested that nearly half (47.7%) of U.S. adults aged 20 to 69 reported taking at least one dietary supplement in the past month. The likelihood of supplement use was greater in females (53.6%) than males (41.6%), older vs. younger people (57%-69% among participants ≥50years old), non-Hispanic whites, higher level of education and of food security. Also, supplement users tend to consume significantly more vitamins A, C, and E, and folate, calcium, and iron from food sources alone. There was no association found between dietary supplement usage and weight status (59).

Dietary supplement use is commonly recommended during pregnancy and lactation. Nevertheless, there are only few reports that analyze the extent of this practice in North America. The primary challenge in NHANES was the small sample size of pregnant women that would provide unreliable estimates of supplement use in this population subgroup. One of the studies in this regard was reported by Suitor and Gardner (60). The researchers analyzed the self-reported rates of supplement use in 344 low-income pregnant women. From those, 86% reported consumption 4 times and more per week and 5% took supplements 2-3 times per week. Another study was reported by Cogswell et al (61) who examined data from NHANES III (1988-1994) to assess iron supplement consumption among women including 295 pregnant and 97 lactating. The author found that 72% of pregnant and 60% of lactating women took iron supplements. In addition, supplement consumption was highly dependent on ethnicity and income. In general, non-Hispanic white women and women with higher incomes were more likely to take supplements than non-Hispanic black or Mexican American and low-income women. Also, more of the women reported taking dietary supplements during pregnancy than during lactation (62). Recently, Branum et al (2013) analyzed data on 1296 pregnant women who participated in NHANES from 1999 to 2006. The goal of the study was to characterize overall supplement use, iron and folic acid use, and RBC folate status. The report showed that about 77% of pregnant women reported use of a supplement in the previous 30 d. Pregnant women reporting supplement use were more likely to be 25 y of age or older (85% vs. 63% by women aged < 25y), have at least some college education, and were more likely to be non-Hispanic white. In addition, pregnant women who reported supplement use were more likely to be in their third trimester (91%) compared to first semester (63%). Approximately 55–60% of pregnant women reported taking a folic acid- or iron containing supplement (63).

Table 2.1 summarizes the prevalence estimates reported here. In addition, one fairly consistent pattern seen across most surveys is that supplement use is more common among older adults, females, Caucasians, people living in the West, former smokers, those with higher incomes and levels of education, and individuals with higher nutrient intakes from diet and higher levels of self-reported health status (34,39,40,42,43,44,45,46,48).

Table 2.1. Prevalence of dietary supplement use in general U.S. population (1971-2013)

Survey/year	Sample characteristics: age/number	Prevalence of supplement use (%)
Third National Health and Nutrition Examination Survey I (NHANES I) 1971-1974	Age:1-74 y n=11227	23 (daily)
NHANES II 1976-1980	Age: 18-74 n=9977	35 (21%-daily, 14%-once a week)
NHANES III 1988-1994	Age: ≥2 month n=33994	40 (prior month)
National Telephone Interview Special Dietary Food Study (1980)	Age: ≥16y n=2991	40 (at least one supplement)
National Health Interview Survey (NHIS) 1986	Age: 2-6y/ n=18162 Age ≥18y/ n=169587	43 36 (previous 14 days)
NHIS 1987	Age: 18-99 y N=22080	23 (daily)
NHIS 1992	Age: ≥18 y N=12005	24 (daily)
NHIS 2000	Age: ≥18 y N=34374	34 (daily)
The Continuing Survey of Food Intake by Individuals (CSFII) 1994–96	Age: ≥ 20 y N=4816 (men) 5056 (women)	42 (men) 56 (women) (any use of supplements)
CSFII (1994)	N=423 adolescents	16 (daily)
The Slone Survey 1998-1999	Age: ≥18 y N=2590	35 (in the prior week)
NHANES 1999- 2000	Age: ≥ 20 y N=4862	52 (in the past 30 days)
NHANES 1999-2002	Age: 0-18 y N=10 136	32 (in the past 30 days)
NHANES 1999-2004	Age: 2-17 y N= 10828	34 (in the past 30 days)
NHANES 2003-2006	Age: ≥1 y N= 18758	49 (in the past 30 days)
NHANES 2007-2008	Age: 20-69 y N=3364	48 (in the past 30 days)

2.3. Dietary supplement use in Canada.

The 2004 Canadian Community Health Survey (CCHS)-Nutrition was the first nationally representative, cross-sectional survey to study Canadian's eating habits after Nutrition Canada National Survey performed in 1972. Before this survey, several studies were conducted to report dietary supplement use among Canadians; however, most of them were not nationally representative (19,25,64, 65,66).

The Food Habits of Canadians (FHC), undertaken in 1997-1998, was a national survey of adult Canadians with a goal to monitor changes in dietary intake. In this survey, 1544 individuals aged 18-65 were randomly selected from five geographic regions across Canada (Atlantic, Quebec, Ontario, Prairies and British Columbia)) and interviewed by a dietitian for a 24-hour dietary recall including information about use of any dietary supplements on the recalled day (68). According to these data, dietary supplement use was reported by 41% of Canadians. Particularly, about 46% of women and 33% of men reported taking at least one Natural Health Product (supplements plus herbal products). The highest prevalence of supplement use was among women aged 50-65 (57%). The most commonly reported nutritive supplements were multivitamins, vitamin C, and calcium supplements, in that order. Supplement users were older, less likely to smoke and perceived their health as better than non-users. Among supplement users, men had higher rates of use of garlic and vitamin C while women used more iron, calcium, B complex (25, 64).

The British Columbia Nutrition Survey (BCNS) was conducted in 1999 by Health Canada and the BC Ministry of Health Planning to obtain comprehensive information on the eating habits of adult British Columbians. This survey included 1823 participants aged 19 to 84 years and involved 90-minute, in-home interviews by a dietitian (65). Overall, almost half of the population (46%) took a supplement on the previous day, and 64% had taken a supplement within the past month. In that study, women were also more likely than men to use supplements, and the prevalence of use increased with age, from 28% of men and 35% of women aged 18 to 35, to 42% of men and 57% of women aged 50 to 65. The most commonly used vitamin and/or mineral supplements were vitamin C, vitamin E and calcium. Among non-vitamin/mineral supplements, glucosamine, chondroitin sulphate, garlic, various oils, echinacea and gingko biloba most frequently were reported (65).

The next data were collected in 2001-2004 by The Tomorrow Project, a prospective cohort study in Alberta aiming to find out more about the cause of cancer (66). The data were obtained from self-administered questionnaires completed by randomly selected 5067 men and 7439 women, aged 35–69 years. Participants who used at least one type of dietary supplement weekly or more in the year prior to the questionnaire completion were defined as supplement users, while the remainder were classified as non-users. According to the study (66), almost 70% of participants were classified as regular users of dietary supplements. This estimate is higher than those reported by previous Canadian surveys (64, 65). The reason for the apparent disparity in prevalence estimates could be because this survey assessed supplement use in adults aged 35–69 year in contrast to individuals 18-65 years old elsewhere. Additional finding of the study is that women were more likely to consume supplements than men (78.7% vs. 61.2%). Among women, the most commonly reported supplements were calcium (60.3%) and glucosamine (20.3%). In contrast, vitamin C (37.4%) and garlic (18.9%) were supplements reported most commonly by men. Also, regular supplement use was higher in older age group (55-70) compared to younger (35-44), i.e. 79.4% and 63.7%, respectively. In addition to that, participants who consumed supplements were less likely than non-users to be smokers, and more likely to report at least five daily serving of fruits and vegetables, and one daily serving of whole-grain foods.

One more study was conducted in Ontario between 2002 and 2003 (19). This survey aimed to assess total vitamin D intake from food and supplements among 3,471 women aged 25-74 years old using a modified Block 1998 (US) food frequency questionnaire (FFQ). The report suggested that 45% of those women reported vitamin D intake from supplements while 38% were multivitamin users. For total vitamin D intake (supplements plus foods), only 62% of women age 25-50, 48% of women age 51-70, and 28% of women age 71-74 had total vitamin D intake that met the AI for their age range.

Poliquin et al (2009) examined the data from the Canadian Multicentre Osteoporosis Study (CaMos). It was a longitudinal observational survey which included a random sample of 9423 men and women aged 25 and over, recruited in nine cities across Canada (Vancouver, Calgary, Saskatoon, Toronto, Hamilton, Kingston, Quebec City, Halifax, and St. John's). The goal of the study was to estimate calcium and vitamin D intake from specific foods and the contribution of supplements to the total intake in Canadian adults. Information on calcium and vitamin D intakes was collected using an abbreviated semi-quantitative food frequency questionnaire (FFQ). According to the report, the proportion of men using dietary supplements was significantly lower than that of women for calcium (22.6% vs. 43.7%) as well as for vitamin D (19.7% vs. 32.4%). Also, the results showed that the centres with the highest reported mean total calcium intake were Saskatoon with 1218 mg/day (in women), and Calgary with 1034 mg/day (in men) whereas Quebec City had the lowest mean total calcium intake for both genders with 895 mg/day in women and 795 mg/day in men. These estimates may be explained by a lower consumption of milk and calcium supplements in Quebec City. Similarly, the highest mean vitamin D intake was reported in Saskatoon (7.3 μg/day in women and 6.0 μg/day in men) while the lowest vitamin D intake was reported in Quebec City (4.2 μg/day in women and 3.4 in men), and in St. John's (4.7 μg/day in women and 4.2 in men). The difference between intakes in men and women was attributed to a greater use of vitamin D supplements by women (67).

Cycle 2.2 of the 2004 Canadian Community Health Survey (CCHS) provided the first national nutrition data since the Nutrition Canada survey was conducted in 1972. This cross-sectional survey provided reliable information about the food and nutrient intakes of

35,107 Canadians (69). Dietary intake data were collected using a modified version of the USDA's Automated Multiple Pass Method for 24-h dietary recall (70, 71). Information about supplement usage was collected as a part of a questionnaire, over the prior 30 days. Users of supplements were asked to specify the type, frequency of supplement consumption, duration, and amount of supplements. Following studies have been done based on this survey.

Guo et al. (24) reported the prevalence of vitamin and mineral supplement use among adults and its association with demographic and lifestyle factors. According to the report, 40% of Canadian adults 19-70 years old reported use of vitamin/ mineral supplements during the prior month. They also observed that more females (48%) than males (23%) and older persons 51% (51 to 70 years) vs. younger 38% (31 to 50 years) and 31% (19 to 30 years) reported use of dietary supplements. In addition, respondents with a self-reported chronic disease were more likely to be vitamin and mineral supplement users than those without a chronic condition. In contrast, respondents with less healthy lifestyle behaviours or of lower socioeconomic status were generally less likely to be vitamin and mineral supplement users (24).

Vatanparast et al. (23) determined trends in calcium intake from foods of Canadian adults from 1970–1972 to 2004 using the data from 3 representative surveys (Nutrition Canada (1970-72), The Provincial Nutrition Surveys (1900-1999) (72), and CCHS 2.2 Nutrition (2004)). The authors concluded that calcium intake only modestly increased from 1972 to 2004 despite the introduction of calcium fortified beverages in 1990s. When supplemental calcium intake was added (2004), mean intake remained below the recommended levels, except for men 19-30 y, but the prevalence of adequacy increased in all age groups, notably for older women over 50-70 years (31%). Nevertheless, the calcium intake of males in every age group was greater than that of females.

Later, using the CCHS cycle 2.2 Nutrition data, Vatanparast et al (2010) examined the association between socio-economic status and vitamin/mineral supplement use in Canada (20). According to the study, about 40% of children aged 1-8 took dietary supplements. Among adolescents aged 14-18 years the percentage was less than 30%. The highest prevalence of supplement intake was among women aged 51 and over (60%). Overall, women tend to take more supplements then men (47% vs. 34%). Supplement use was generally more common among people in higher- than lower-income households. Similarly, supplement consumption tended to rise with level of education (Table 2.4). Also, taking supplements was significantly lower among people with moderate and severe food insecurity, compared with those who were food secure.

Shakur et al (21) analyzed use of folic acid-containing supplements among individuals 1-70 years. They estimated that among females of reproductive age, folic-acid supplements were consumed by 15%, 23% and 29% of female aged 14-18, 19-30, and 31-50 y, respectively. The highest folic acid intake was in children 4-8 y. In addition, supplement use was more prevalent among females than in males in all age groups 14 and older. In general, older individuals and those being food-secure, with healthier lifestyles, higher consumption of fruit and vegetables, and favorable socio-demographic backgrounds were more likely to use vitamin and mineral supplements (20, 24). Another report presented by Shakur et al (73) was also based on the 2004 CCHS 2.2 Nutrition. According to this study, the overall prevalence of any supplement use in the population was 40%. Vitamin C was the most commonly consumed nutrient overall, except among women 51y and older who meanly consumed supplemental vitamin D and calcium. Children 4-8 y had the highest percentage of vitamin/mineral consumption among participants aged 1-18 years old. Among adults, women 51 and over had the highest prevalence of use of any supplements (60%), multivitamin/mineral (MVMM) supplements (37%) and for all nutrients except iron (Table 2.6, 2.7).

One more report done in 2009 by Blanchet et al (74), explored the prevalence of supplement intake by Quebec adults (1256 men and 1373 women) aged 19 years and older during the month preceding the survey. According to the report, 34% of Quebec adults used dietary supplements. Women were more likely (42%) than men (25%) to consume dietary supplements. Also, women aged between 51 and 70 years were more likely to take supplements than younger women. These results showed that the prevalence of dietary supplement use among Quebecers is lower than among other Canadians (42%).

The two most recent studies were based on the 2007-2009 Canadian Health Measures Survey conducted by Statistic Canada (75). Whiting et al (2011) determined the prevalence of meeting DRI recommendations and the role of vitamin D supplement use among Canadians aged 6–79 y. According to their report, 31% of Canadians aged 6–79 y reported taking at least one supplement containing vitamin D in the previous month. Approximately 95% of all consumed supplements were in the vitamin D3 form. Supplement users had significantly higher 25(OH) D concentrations than did nonusers, and no seasonal differences were found (76).

Another study explored correlates of optimal RBC folate concentration and characteristics of folic acid supplement users in a sample of Canadian women of childbearing age (WCBA) aged 15-45. The report showed that 25% of Canadian WCBA consumed supplements containing folic acid. A higher prevalence of folic acid supplement users than non-users were in higher income quartile (29% and 15%, respectively). Also, folic acid supplement users were also more frequent B12 supplement users and tend to consume 3 and more serving of fruits and vegetables per day (75).

Table 2.2 summarizes the prevalence estimates of supplement use reported for Canada.

Table 2.2 Prevalence of dietary supplement use among Canadian population (1972 to 2012).

Survey/ year of data collection	Reference/ year	Sample characteristic n/year	Prevalence of supplement use (%)		
			total	men	women
The Food Habits of Canadians (FHC) (1997-98)	Troppmann et al. (2002)	N=1544 Age: 18-65y	41 (prev. day)	33 (prev. day)	46 (prev. day)
The British Columbia Nutrition Survey (BCNS) (1999)	Barr (2004)	N=1823 Age: 19-84 y	46 (prev. day) 64 (prev. month)	28-42 (prev. month)	35-57 (prev. month)
The Tomorrow Project (2001-2004)	Robson et al. (2007)	5067 men 7439 women Age: 35–69 y	70	61	79
			at least one supplement weekly or more in the prior year		
Ontario survey (vit. D) 2002-2003	Anderson et al. (2010)	3,471 women Age:25-74 y	-	-	45 (v. D) 38 (MVMM) (within two years prior)
Canadian Multicentre Osteoporosis Study (1997-98)	Poliquin et al. (2009)	N=9423 Age: ≥25	-	23 (Ca) 20 (v. D) (prev. year)	44 (Ca) 32 (v. D) (prev. year)
Canadian Community Health Survey (CCHS) 2.2 nutrition (2004)	Guo et al. (2009)	N=15,553 Age: 19-70 y	40 (prev. month)	32 (prev. month)	48 (prev.month)
	Vatanparast et al. (2010)	N=34,818 Age: ≥1y	-	34 (prev. month)	47 (prev.month)
	Shakur et al. (2012)	N=34,381 Age: ≥1y	40 (prev. month)	35 (prev. month)	51 (prev. month)
Canadian Health Measures Survey (2007-2009)	Whiting et al. 2011	N=5306 Age: 6-79 y	31 (v. D) (prev. month)	-	-
	Colapinto et al. (2012)	N=1162 (women) Age: 15-45y	-	-	25 (folic acid) (prev.month)

According to the viewed surveys, the trend of dietary supplement use in Canada is similar to that in the United States. Regular use of dietary supplements is higher among female than men and among older individuals vs. younger. Also, individuals with more education, higher income, previous smokers, and people who consumed at least five daily serving of fruits and vegetables, and one daily serving of whole grains are associated with a greater likelihood of dietary supplement use. Multivitamins/multimineral supplements, vitamin C, calcium, and vitamin D are the most commonly reported dietary supplement across all age groups. Particularly, use of calcium and vitamin D containing supplements is higher among women aged 50 and over. (Appendix I presents additional data of potential intakes)

Table 2.3. Rea et al (2012) Strategic information for the nutrition industry. U.S. Market overview (38)

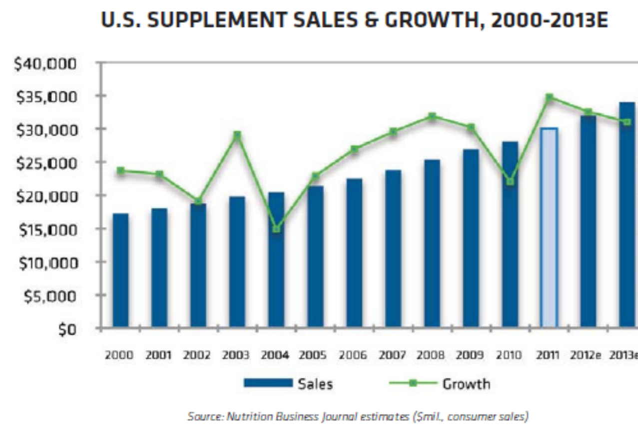


Table 2.4. Vatanparast et al (2010) Socio-economic status and vitamin/mineral supplement use in Canada (20)

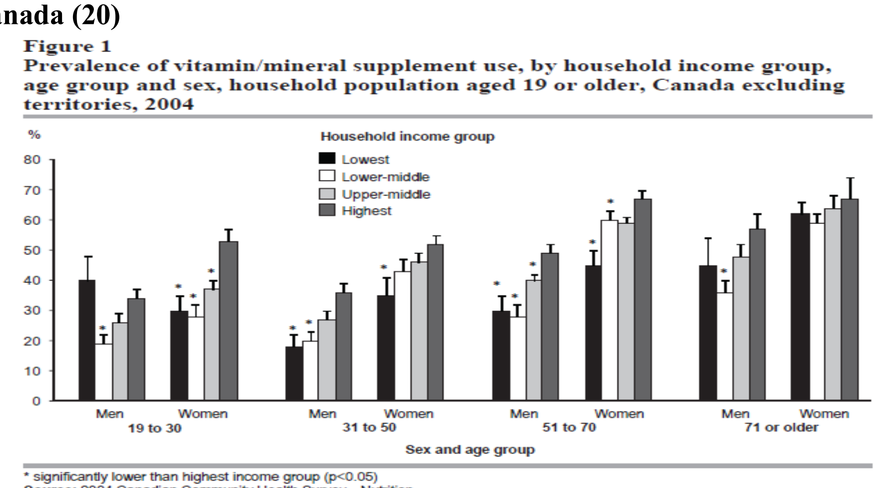


Table 2.5. Shakur et al (2012) A Comparison of Micronutrient Inadequacy and Risk of High Micronutrient Intakes among Vitamin and Mineral Supplement Users and Nonusers in Canada (73)

Prevalence of MV supplement consumption by sex/age groups among all responders: vitamins.

				Consumption of a supplement containing									
Group	*n*	Nutrients, *n*/supplement	Any VM	MVM[2]	Vit A	Vit C	Vit D	Vit B-6	Folic acid	Vit B-12	Thiamin	Riboflavin	Niacin
Children													
1–3 y	2192	9.0 (0.2)	38 (2)	35 (2)	35 (2)	36 (2)	35 (2)	32 (2)	31 (2)	31 (2)	32 (2)	32 (2)	32 (2)
4–8 y	3343	9.7 (0.2)	45 (1)	42 (1)	41 (1)	44 (1)	41 (1)	42 (1)	38 (1)	41 (1)	40 (1)	40 (1)	40 (1)
9–13 y	4192	7.6 (0.2)	33 (1)	25 (1)	24 (1)	31 (1)	24 (1)	24 (1)	23 (1)	24 (1)	23 (1)	23 (1)	24 (1)
Males													
14–18 y	2397	6.9 (0.4)	23 (2)	15 (1)	14 (1)	21 (1)	15 (1)	14 (1)	14 (1)	14 (1)	14 (1)	14 (1)	14 (1)
19–50 y	4646	6.9 (0.4)	29 (1)	20 (1)	18 (1)	25 (1)	19 (1)	19 (1)	19 (1)	19 (1)	19 (1)	19 (1)	19 (1)
≥51y	4324	5.6 (0.2)	41 (1)	28 (1)	26 (1)	32 (1)	28 (1)	26 (1)	26 (1)	27 (1)	26 (1)	26 (1)	26 (1)
Females													
14–18 y	2346	6.0 (0.3)	29 (2)	17 (1)	16 (1)	24 (2)	17 (1)	16 (1)	15 (1)	15 (1)	16 (1)	16 (1)	16 (1)
19–50 y	4766	5.9 (0.2)	42 (1)	29 (1)	25 (1)	33 (1)	28 (1)	27 (1)	27 (1)	27 (1)	27 (1)	27 (1)	27 (1)
≥51y	6175	4.5 (0.1)	60 (1)	37 (1)	31 (1)	38 (1)	44 (1)	31 (1)	30 (1)	32 (1)	30 (1)	31 (1)	30 (1)
Overall	34,381	5.9 (0.1)	40 (1)	28 (1)	25 (1)	31 (1)	28 (1)	26 (1)	25 (1)	26 (1)	25 (1)	25 (1)	25 (1)

[1] Values are percentage (SE). MVM, multi-vitamin/mineral supplement; Vit, vitamin; VM, vitamin/mineral.

[2] MVM defined as any supplement containing ≥3 vitamins/minerals.

Table 2.6. Shakur et al (2012) A Comparison of Micronutrient Inadequacy and Risk of High Micronutrient Intakes among Vitamin and Mineral Supplement Users and Nonusers in Canada (73)

Prevalence of MV supplement consumption by sex/age groups among all responders: minerals.

		Consumption of a supplement containing				
Group	*n*	Calcium	Phosphorus	Magnesium	Iron	Zinc
Children						
1–3 y	2192	21 (2)	16 (1)	2 (1)	20 (1)	2 (0.4)
4–8 y	3343	28 (1)	21 (1)	3 (1)	24 (1)	2 (0.4)
9–13 y	4192	16 (1)	12 (1)	4 (1)	15 (1)	3 (0.4)
Males						
14–18 y	2397	14 (1)	10 (1)	9 (1)	11 (1)	8 (1)
19–50 y	4646	19 (1)	12 (1)	18 (1)	15 (1)	17 (1)
≥51 y	4324	29 (1)	18 (1)	25 (1)	20 (1)	23 (1)
Females						
14–18 y	2346	15 (1)	8 (1)	11 (1)	14 (1)	9 (1)
19–50 y	4766	30 (1)	14 (1)	25 (1)	24 (1)	19 (1)
≥51 y	6175	48 (1)	18 (1)	31 (1)	24 (1)	28 (1)
Overall	34381	28 (1)	15 (0.4)	20 (0.4)	20 (0.4)	17 (0.4)

[1] Values are percentage (SE). VM, vitamin/mineral.

2.4. Dietary supplement use by smoking status.

Only a few studies collected information on dietary supplement use particularly those containing vitamin C by smoking status. Zondervan et al (1996) using the Monitoring Project on Risk Factors for Chronic Diseases in the Netherlands (MORGEN) data examined dietary and supplementary intakes of antioxidants in different smoking groups. The results of this study indicated that heavy and moderate smokers in both men and women have a lower vitamin C intake from their diets compared to never-smokers. In contrast, smokers seemed to use supplements containing vitamin C more frequently than never or ex-smokers. Particularly, 15.3% of male heavy smokers consumed vitamin C supplements compared to only 12.2% of males who never smoked. The highest frequency of vitamin C supplement use was reported by female light smokers (23.2%) and female heavy smokers (21%) (104). Troppmann et al (2002) presented only the prevalence of any Natural Health Product use by smoking status (64). According to this study, about 15.7% of cigarette smokers reported use of any dietary supplement use on the day of the 24h recall. Radimer et al (2004) analysing the NHANES 1999–2000 data, reported that smokers were less likely to take vitamin C supplements than never smokers (9.2% vs. 12.8%) whereas about 14.8% of former smokers consumed vitamin C containing supplements (29). Schleicher et al (2009) reported serum vitamin C and the prevalence of vitamin C deficiency in adults aged ≥20y living in the United States using NHANES 2003-2004. According to the results, mean serum concentration of vitamin C of all smokers was about 33% lower than that of all non-smokers. In addition to that, a frequency analysis of smoking by supplement usage in this population showed that those aged ≥60 y who did not use supplements were more likely to be smokers than those who did (22% compared with 12%) (105). Robson et al (2008) determined that about 63.8% of smokers and 71.3% of non-smokers aged 35-69 y adults taking part in a longitudinal cancer cohort study in The Tomorrow Project regularly used dietary supplements (66). The study done by Guo et al (2009) presented that among all Canadian population aged 19-70y (CCHS cycle 2.2

Nutrition), almost 33% of smokers, 45% of former smokers and 41% of non-smokers used vitamin and mineral supplements in the prior 30 days (24). Garriguet (2010), analyzing the same data, observed that almost a third of all Canadians used supplements containing vitamin C, which add approximately 100 mg to total average daily intake. In regard to smoking status, 25% of smokers and 32% of non-smokers reported the use of vitamin C containing supplements. Nevertheless, smokers, people with low consumption of fruits and vegetables tended to have inadequate intake of vitamin C. Particularly, when smokers' greater vitamin C requirements were considered, about 52% of them had inadequate vitamin C intake compared to only 14.6% of non-smokers from food sources. When supplement use was included in the analysis, the greatest impact of supplement consumption was observed for smokers (10-persentage-point reduction). Interestingly, Quebec, among other provinces, had the highest dietary intake of vitamin C, but the lowest percentage of consumers of vitamin C supplements (18).

2.5. The contribution of dietary supplements to total usual dietary intakes.

Dietary supplements constitute an important source of nutrients for large segments of the population. Supplements have the potential to fill dietary gaps but, at the same time, may increase intakes above tolerable upper levels. Due to these reasons, there is increased interest in research evaluating the role of supplement in meeting and/or exceeding nutritional requirements. Previous the U.S. nationally representative survey data (1994-1996) examined only differences in vitamin intakes from foods between users and non-users of dietary supplements among older adults (≥45-y old) (86). Using the same data, Murphy et al (16) evaluated the prevalence of nutrient adequacy for 17 nutrients. Sebastian et al (87) observed vitamin intakes by dietary supplement use in older adults in the Continuing Survey of Food Intakes by Individuals (1994-1996). However, since then, the use of dietary supplements has greatly increased (33).

Bailley et al (56), using the data from 2003-2006 NHANES, the most recent available nationally representative, cross-sectional survey, analyzed total folic acid intake from food and dietary supplements in adolescents and adults aged 14 and over. In general, men had higher dietary and total nutrient intake than women. Use and mean contribution from folic supplements was highest for individuals aged 50-70-years and was 436±21 mg/day; however, about 5% of these individuals were above UL from dietary supplements alone. The use of dietary supplements lowered the prevalence of individuals who did not meet the EAR, especially in women by 8-10% depending on age. Nevertheless, even with use of supplements, 19% of 14-18-y-old and 17% of 19-30-y-old women did not meet the EAR. Among men, no significant differences were observed across all age groups between supplement users and non-users, except men >51 y who had higher total folate intake compared with referent group. Among both sexes, non-Hispanic whites had higher total folate intakes than did non-Hispanic blacks and Mexican Americans. This may be explained by higher prevalence of supplement use among non-Hispanic whites than other racial-ethnic groups (39% vs. 19%). On the other hand, dietary supplement use increased the prevalence of excessive total folate intakes in non-Hispanic men and women and was about 5% versus 1% in non-Hispanic blacks and Mexican Americans. However, the rates of intakes above the UL were significantly higher among children and young adolescents (57) versus persons aged >14 y. Mean folic acid intakes and the prevalence of intakes above the UL greatly increased when the contribution from dietary supplements was included. More than half of dietary supplement users exceeded the UL for total folic acid (fortified food + supplements) as compared with nonusers (5%). The highest prevalence of intakes above the UL (33%) was in males aged 4–8-y and the lowest prevalence of intakes above the UL (7%) was in 9–13-y-old males and females. With respect to the race-ethnicity comparisons, the prevalence of total folic acid intakes above the UL was similar to individuals >14 y old: significantly higher among non-Hispanic whites than among non-Hispanic blacks and Mexican Americans (57).

For nutrients that did not have an EAR at that time (calcium and vitamin D), the effect of supplement use on the prevalence of inadequacy was assessed by Adequate Intake (AI) with assumption that intakes at or above the AI can be adequate (58). Bailley et al (58), analysing total calcium and vitamin D intakes in the US population aged 1 y and older, concluded that males and females aged 1-8 y had the highest proportion meeting the AI for dietary and total intake of calcium, but only 15% of 9 to 13-y-old and 13% of 14-18-y-old females met the AI. In general, dietary supplement use did not have a significant impact on total calcium intake across all aged groups except for the older. For users, calcium supplements provided the AI recommendation for about 15% of males ≥51y old and for about 30% of females ≥ 51. The prevalence of intake above UL was higher for total calcium intake compared with calcium intake from diet alone, but still small (2%) except for males aged 14-18 y, and females 51 and older (4%). The vitamin D intake that met the AI from diet only sources was the highest among younger Americans (males 1-8-y and females 1-13-y old) ranging from 47 to 72% and the smallest among individuals over the age of 51 y (less than 7%). When total intake was examined, dietary supplements increased the prevalence of meeting the AI in all age groups, but most dramatically in those aged 51y and older (up to 44%). Nevertheless, for total vitamin D intake, both genders ≥71 and females 14-18 y had the lowest prevalence of meeting AI. Thus, a large percentage of older adults fail to meet the recommendations for vitamin D intake. Less than 1% of all individuals exceeded the UL when total intake was analysed.

Another study, conducted by Bailey et al (17), examined the impact of supplement use on total usual intake of minerals such as calcium, iron, magnesium, zinc, phosphorus, copper, potassium, and selenium in adults ≥19 years old. As was expected, supplement users tended to have higher usual mean intakes of minerals from their diets than did non-users, especially women. Dietary supplement use lowered the prevalence of inadequate total intakes for every mineral examined in adult men and women, especially for magnesium (21% vs. 66%), calcium (20% vs. 51%), copper (0.1% vs. 20%), and zinc (0.1% vs. 13%).

Nevertheless, about 20% of supplement users reported intakes below the EAR for calcium and magnesium. Because dietary supplements do not usually contain large amounts of phosphorus and potassium, they did not substantially contribute to total intakes of the minerals. The prevalence of adults who exceeded the UL for calcium, zinc, iron, and magnesium was higher in users than non-users. Thus, among supplement users (when both genders were combined) about 6% of persons exceeded the UL for iron, 9%- for zinc, and about 6% for magnesium.

Using the same 2003-2006 NHANES data, Bailey et al (83) also analysed vitamin intakes among US adults aged 19 y old and over by dietary supplement use. They considered vitamins such as folate, vitamin B-6, B-12, A, C, D, E, and K. In contrast to minerals (17), there were no significant differences between intakes of vitamins from foods only among supplement users and non-users. Calculating total intakes of users (from foods plus supplements), significantly more non-users were at risk of inadequacy of every vitamins. Thus, regardless of sex, the greatest contribution of supplement use to lowering risk of inadequacy was observed for vitamin D (25% vs. 95%), E (5% vs. 95%), vitamin A (2% vs. 58%), vitamin C (3% vs. 48%), and folate (1% vs. 14%). About 12% of women non-users aged 19 to 30 years had inadequate intake of vitamin B-12, compared with <0.5% of women who used vitamins. Even among supplement users, about 40% of adults aged 19 to 30 years had inadequate vitamin D intakes and about 13% had inadequate total vitamin E intakes. Among older women, from 35% to 40% who did not use B-6 containing vitamins, did not meet the EAR, compared to 0.5% of inadequacy among those who used vitamins. The prevalence of intakes above UL was observed only among supplement users. Thus, about 7% of those adults exceeded the UL for folic acid, 5% of subjects ≥50-y exceeded the vitamin A and B-6 UL. Approximately 2% of users exceeded the UL for vitamin C and less that 0.7%- for vitamin D and E (83).

An additional analysis was performed by Bailey and colleagues to examine if dietary supplements improve micronutrient sufficiency in children and adolescents 2 to 18 years old (84). As was expected, use of supplements lowered the prevalence of nutrient intakes below EAR for many vitamins and minerals, especially among those aged 14-18 years. Non-users had a higher prevalence of inadequacy in their usual intakes of calcium, vitamin A, C, D, and E for all age groups. However, even among supplement users, more than one-third of all children failed to meet calcium and vitamin D recommendations. About half of magnesium-containing supplement users did not meet the EAR. The prevalence of inadequate intakes of phosphorus, copper, selenium, zinc, folate, vitamin B-6 and B-12 among 2-8 y was negligible for both users and non-users. Among 9-13 year olds, there were no significant differences in phosphorus, copper, selenium, and vitamin B-12 intakes between users and non-users, but were a higher prevalence of inadequate intake of magnesium,, vitamin A, C, and E was observed. Also, supplement use was associated with increases in the prevalence of intakes above the UL for iron (6%), zinc (52% vs. 17%), folic acid (49% vs. 3.2%), and vitamins A (45% vs. 5%), and C (and copper and selenium (more than 7%) among 2-8 year olds) among all age groups (84).

In Canada, the 2004 Canadian Community Health Survey (CCHS) is the most recent nationally representative survey. Using these data, Shukur et al (73) analyzed micronutrient adequacy and risk of high micronutrient intakes among vitamin and mineral users and non-users aged from 1 year and above in Canada. The prevalence of inadequacy of nutrient intakes from foods only was very low for all nutrients except vitamin D (up to 85-91%) and calcium among children 1-13 y. Among individuals ≥14 y, the prevalence of intakes below the EAR was higher only for vitamins A (29-46%) and D (74-93%), magnesium (23-68%), and calcium (24-86%). When supplement consumption was included, the prevalence of inadequacy among users for most nutrients was zero; however, there still remained magnesium (12-29%), calcium (16-38% and 55% in females aged 14-18 y), and vitamin D (16-36%) inadequacy across all age groups. Obviously, use of supplements contributed to an increase of intakes above the UL for all nutrients. Particularly, above 10% of users in some age/sex groups had intakes of vitamins A, and C, niacin, folic acid, iron, zinc, and magnesium greater than the UL and more than 80% for vitamin A and niacin in children 1-3 y (38). Garriguet (18) reported the effect of supplement use on vitamin C intake. He noted that supplement consumption increased Canadians' overall vitamin C intake by 100 mg to an average of 233 mg a day. However, the overall impact of supplements was not significant and reduced the prevalence of total population with inadequate vitamin C intake only by 5 percentage points to 17%. This is because only 31% of individuals consumed vitamin C supplements and they are more likely to already have adequate vitamin C intake. Based on diet alone, non-users were more likely to have inadequate intakes of vitamin C than supplement users.

Vitamin and mineral supplements offer the potential to improve the micronutrient intake of people with a nutrient-poor diet. Expectedly, the prevalence of inadequate total micronutrient intakes is lower in adults who use dietary supplements compared with those who do not use them (16, 56, 58, 87). However, people at risk for nutrient inadequacy, or in need of more nutrients because of disease risk, are more likely to not take supplements. In fact, a number of American studies suggested that adult users have higher intakes of nutrients from their diets than non-users (31, 86, 87). The contribution of nutrients from dietary supplements to total intakes varies among different studies. In the United States and Canada, the most significant reductions in the prevalence of intakes below the EARs because of dietary supplement use were observed for magnesium, calcium, folic acid, vitamin A and D especially among older adults since they are more likely to use dietary supplements (17, 56, 58, 73, 83). On the other hand, supplement use is also associated with an increased risk of intakes above the UL (31, 56) as well as adverse events (88). Also, it is important to better measure the levels of nutrients in dietary supplements (81). Therefore, it is crucial to evaluate the contribution of vitamin and mineral supplement use on total usual nutrient intakes in the assessment of nutritional status of population.

2.6. Health issue of Aboriginal people living in Canada.

Aboriginal people (First Nations, Métis and Inuit), original inhabitants of Canada, comprise about 3.7% of the total Canadian population. Currently, there are about 630 First Nation communities spread across Canada. According to the 2006 Census, First Nations people comprised 60% of all people who identified themselves an Aboriginal person and about one third of them have been living on reserves (89). On average, the Aboriginal population is considerably younger than the non-Aboriginal population. Thus, about 47% of the Aboriginal population is under the age of 25, compared to 30% of the non-Aboriginal population (90). Despite the younger average age of these populations, the health of Aboriginal peoples is worse than that of the general Canadian population. The health disparities that exist between Aboriginal and non-Aboriginal Canadians are driven by social, economic and environmental features. In fact, Aboriginal people have less education, higher unemployment rates and lower incomes than other Canadian adults (90,91,92).

In general, Aboriginal people experience higher rates of chronic and infectious diseases, infant mortality, and lower life expectancy. Their health status is primarily affected by poverty, social instability, and alcohol and drug addiction (91,92,93). For instance, the prevalence rate of smoking by First Nations in Canada is 57% while only 20% in the general Canadian population. Among those, younger First Nations adults (18-25y) report the highest rates of daily smoking. Almost two thirds of First Nation adults used alcohol in the preceding 12 months, and about two-thirds of them reported drinking heavily (90). However, many health problems experienced by Aboriginal people such as obesity, heart disease and diabetes, are related to diet (2,93). The nutrition obtained through food is essential for health and well-being. For Aboriginal groups, healthy eating includes the consumption of traditional food. Traditional food, harvested by hunting, fishing and gathering of different wild plants and animals, is nutritionally, culturally and economically important for Aboriginal people. It provides rich nutritional benefits and is healthier compared to market food. Especially, traditional food may contribute to vitamins A, C, D, E, magnesium, calcium, iron, and protein as well as fiber intakes (4,94). Nevertheless, because of changes in lifestyle and food choices for the last few decades, Canadian Indigenous people have experienced a nutrition transition that resulted in lower use of traditional food (3,90,95,96). Instead, this population has been eating more market products of lower nutritional quality and higher amounts of fat and sugar (96,97). In general, these changes in food choices may explain development of nutrition-related health problems. Particularly, overweight, obesity, and inadequacy of intake of several nutrients are highly prevalent among Canadian Aboriginal population (5). These health conditions, in turn, increase the risk of anemia, type 2 diabetes, gestational diabetes, cardiovascular diseases (CVD), and hypertension. For example, according to the 2008-10 First Nations Regional Health Survey (RHS), overall, 16.2 % of First Nations adults have been diagnosed with diabetes. Of those having diabetes, most (80.8%) have been diagnosed with type 2 diabetes, 9.4% with type 1 diabetes and 5.8% report having gestational diabetes (90). Another survey of First Nations Living Off-Reserve, Inuit, and Métis Adults (93) showed that diabetes was significantly more prevalent among First Nations (9.3%) and Métis (7.5%) adults than among non-Aboriginal adults (6.5%). Conversely, diabetes was less prevalent among Inuit adults (4.9%) (90).

2.7. Dietary and supplement intake among Aboriginal people in Canada.

Several studies have been done in the assessment of adequacy of nutrient intake in Aboriginal people. Those studies consistently reported low intakes of calcium, vitamin A, vitamin D, vitamin C, folate and magnesium (6,7,8,9,10,11). However, all of them are based on food intake alone. Only a few studies collected information about supplement use among Canadian Aboriginal population.

Nakano et al (9), using 24-h recall, described adequacy of nutrient intakes and anthropometry of 10-12-year-old Dene/Métis and Yukon children in the Canadian Arctic. They reported that about 25% of children took dietary supplements. However, since the information about consumed supplements was not sufficiently detailed, supplement intake was not incorporated into the study (9).

Similarly, the 2002 Nutrition and Food Security in Fort Severn survey conducted in Ontario showed that approximately 10% of Aboriginal women were taking vitamin and mineral supplements; however, further detail about supplement use was not presented (6). Also, the survey of Nunavut Inuit preschool children, aged 3–5 y indicated that about 21% of all children took dietary supplements (8).

Using The Aboriginal Children's Survey 2006 data (98), Findlay and Janz examined the association of family and social conditions with general health of First Nations children living off reserve, Inuit and Métis children younger than 6 years old. They reported that, overall, 43% of First Nation, 29% of Inuit and 49% of Métis children took multivitamins. Particularly, supplements containing vitamin D were reported by 16% (First Nations), 17% (Inuit) and 19% (Métis) of children aged 6 to 11 months old; and about 7% (First Nations), 19% (Inuit) and 7.0% (Métis) of 1-2 year-olds children (10,11).

Kozicky et al (99) used the Healthy Foods North nutrition and lifestyle intervention programme's (HFN) data of three communities in the Northwest Territories with the goal to analyse supplement use and to compare total intake of supplement users and nonusers. Information about supplement use was collected from a population-specific quantitative food frequency questionnaire (FFQ). About 23% of participants aged 19-84 years (45 males and 147 females) reported at least one dietary supplement in the past 30 days. Multivitamins were the most common supplement, followed by vitamin C, and iron. Vitamin D containing supplements were taken by only 3% of participants. Interestingly, the mean intake was not significantly different between supplement users and non-users (99). Using the same data, Shaefer et al (7) assessed supplement consumption among women of childbearing age (19-44 years). Only 11% of the women (7) reported supplement use. One third of all supplements were multivitamins, 25%- iron, 25%- calcium with vitamin D, and 8%- vitamin A.

To sum up, the dietary transition among Canadian Aboriginal people is associated with decreased diet quality. This leads to development of diet-related chronic diseases, such as obesity and type 2 diabetes, which, recently, are increasing among Aboriginal peoples. Therefore, it is critical to conduct a comprehensive assessment of diet of Aboriginal people. Several studies based on food and beverage intakes have been conducted in the assessment of diet of different groups of Indigenous people. Nowadays use of dietary supplements is common among Canadian and Aboriginal population. However, there are only a few studies that collected information about supplement use but none has integrated them in calculating nutrient adequacy. To better analyze diet of Indigenous people, there is a need to include all possible sources of nutrient intake including traditional food, market food and beverages, and supplement use. Table 2.7 presents the prevalence of dietary supplement use among Canadian Aboriginal population.

Table 2.7. Prevalence of dietary supplement use among Canadian Aboriginal population (2000-2012)

Survey/Study year	Reference/year	Sample characteristics age/gender/number	Prevalence of supplement use (%)
Centre for Indigenous Peoples' Nutrition and Environment (CINE) McGill University 2000-2001	Nakano et al. (2005)	Dene/Métis and Yukon Children aged 10-12y N=222	25%
Nutrition and Food Security in Fort Severn survey, Ontario, 2002	Lawn & Harvey (2004)	First Nation women aged 15-44 y N=66	10%

Nunavut Child Inuit Health Survey 2007–2008	Hayek et al. (2010)	Nunavut Inuit children, aged 3–5 y N=282	21%
Aboriginal Children's Survey, 2006	Findlay & Janz 2012	Aboriginal children aged< 6 y n = 12,845	First Nation-43% Inuit- 29% Métis- 49%
Healthy Foods North nutrition and lifestyle intervention programme (HFN) 2007-2008	Shaefer et al. 2011	Inuit women aged 19-44 y n= 106	11%
HFN 2007-2008	Kozicky et al. 2012	Inuit adults aged 19-84 y 45 males 147 females	23% (at least one sup. in the past 30 days) 3%-vit.D

2.8. Methods of estimation of total nutrient intake from food sources and dietary supplements.

Combining supplement use with food intake data presents several challenges. In this section, the following methodologies integrating supplement use into total dietary intake will be presented: Carriquiry's method, Bailey's methodology, four methods proposed by Garriguet, and the National Cancer Institute (NCI) method.

Carriquiry (77) published strategies to combine dietary and supplemental sources of nutrients. According to this report, it is important to determine whether nutrient intake from supplement sources is also subject to day-to-day variability. If nutrient intake from supplement is assumed to be the same from day to day, then total nutrient intake would be easily calculated by adding the daily nutrient consumption from both sources, and applying the statistical Iowa State University (ISU) method (78) to obtain the usual total nutrient intake distribution (77). In the absence of the information, one possible approach consists of the following steps. Using only food intake data, apply the ISU method, which reduces day-to-day variability in intakes, to obtain adjusted individual usual intakes in the original scale. Then, from the frequency information on supplement intake, compute a daily individual intake of nutrient from supplements by dividing the reported dose by its frequency. Thus, the sum of both intakes, one adjusted and one not adjusted, constitutes an estimate of the individual's daily usual total intake that can be used for estimating the distribution of total nutrient intake. Standard errors can be obtained using bootstrap. This approach, however, assumes zero day-to-day variability in nutrient intake that is unlikely to be the case, and this may result in biased estimates of quantities such as the prevalence of nutrient inadequacy or excess above the upper levels. However, the mean total nutrient intake can be reliable. A frequency instrument doesn't allow for estimation of the day-to-day variance in supplement intake, therefore, replicate 24-h recalls could be extended to collect supplement intake data together with food intake data, and daily intake from both sources can be combined before adjustments are made. On the other hand, it needs to consider the individuals who use supplements infrequently. Observing two non-consecutive 24-h recalls of each individual, the distribution of nutrient intake from supplements will have a spike at zero corresponding to the non-consumers and to some of the occasional consumers who by chance did not consume the supplement during either of two days. Thus, additional data are needed to separate the true from the occasional zeros. For collecting information on the propensity to consume supplements, a propensity questionnaire similar to the one that was proposed by the National Cancer Institute (NCI) (79), which separates true non-consumers from occasional consumers before analysis, could be used to complement the supplement intake information provided by the 24-h recalls (79a).

Bailey et al (56) combined data on dietary folate from foods and folic acid from dietary supplements using the 2003-2006 NHANES data. They used the Carriquiry's methodological framework to derive total folate intake from the 24-h recall data and the 30-d frequency questionnaire of dietary supplement use. At first, the dietary folate intakes reported on the 24-h dietary recalls were adjusted for within-person variability with the use of the bias-corrected best power method to obtain a set of intermediary values that reflected the distribution of usual nutrient intake from food sources (78,80). Each of the intermediary values was based on data from particular individuals, for whom additional data that concerned supplement use were available. Next, the individual's reported average daily dose of folic acid from dietary supplements was added the intermediary value to produce a final set of adjusted values that reflected the distribution of usual intake of folate in DFE (1 DFE=1mg food folate=0.6mg folic acid from supplements) and folic acid separately in micrograms (77,80). Thus, dietary and total nutrient intakes were estimated in 2 ways: 1) dietary and total folate in DFE and 2) dietary and total folic acid in micrograms, because the DRIs are constructed in this manner. The estimated average requirement (EAR) is for folate in DFE, but the Tolerable Upper Intake Level (UL) is for folic acid in micrograms. However, the analysis that compared mean intakes of the groups with the UL is for synthetic folic acid only, ie, food folate does not contribute toward the UL. Mean dietary and total folate intake were compared with EAR, and mean dietary and total folic acid were compared with the UL to determine the proportion of the population that meets or exceeds these recommendations, respectively. Some methodological concerns must, however, be acknowledged. First, all estimates of dietary intake were adjusted for within-individual variation, and these estimates assume that reported nutrient intake from food sources on any given 24-h recall day are unbiased and that the self-reported supplement intake reflects true long-term supplement intake. Second, the folic acid content of dietary supplements is also based on label values; recent analytic data suggest that label values may exceed actual amounts (81).

Garriguet (82), using CCHS 2.2 data proposed four different methods for incorporating intake from supplements into intake from food. The estimates of dietary intake from food were based on a 24h-recall with second recall of a subsample and estimates of supplement use were based on self-reported dietary supplement intake during the last 30 days. In method 1, he added the average intake of the selected nutrient from vitamin and mineral supplements to the first 24-hour dietary recall, and if available, to the second. After that, he adjusted the first dietary recall with the second using Software for Intake Distribution Estimation (SIDE) which “removes” within-individual variation (78). Then, he calculated the percentage of the population whose intake of the selected nutrient is below a given threshold using the estimated average requirement (EAR) cut-off method. In the second method, he, at first, calculated usual individual intake of the selected nutrient based on the two dietary recalls using SIDE and then, added intake of supplement. In methods 3, Garriguet divided first the population according to whether they obtain the selected nutrient from supplements. Then, using SIDE and EAR cut-point method, he estimated the prevalence of non-users with inadequate intake of the nutrient (foods/beverages only). Next, using method 1, he estimated the percentage of supplement users with inadequate intake of the selected nutrient (from food and supplements). Finally, he calculated the combined overall estimate of inadequate intake of the nutrient with formula: $P[Xt<EAR]=(1-a)P[Xsnu<EAR]+aP[Xsu<EAR]$ where” Xt” - total nutrient intake; “Xsnu” - supplement non-users’ nutrient intake from food/beverage; Xsu - supplement users total intake, and “a” - the percentage of supplement users. In method 4, Garriguet, after dividing the population according to whether they are supplement users and non-users he calculated supplement non-users’ usual nutrient intake from food and beverages. After that, Garriguet calculated supplement users’ usual intake of the selected nutrient from food only, and then, added their average intake from supplements. Lastly, he combined results from two populations, and calculated the prevalence of inadequacy of nutrient intake for the total population. The author observed that, when estimating the percentage of the population with inadequate vitamin C intake, there are interpretation problems while using Method 1, 2 and 3 because the 95% confidence intervals for the prevalence of inadequate vitamin C intake falls outside the expected maximal-minimal values. However, if using method 4, every estimate is equal to or within the maximal-minimal values. While estimating the prevalence of vitamin D and calcium inadequate intake, adequate intake (AI) was used as a

cut-off, but it doesn't represent the percentage of the population with inadequate intake. No interpretation problems arise with using the four methods for calcium estimates except methods 1 and 2 for vitamin D estimates which are solved with methods 3 and 4. For dietary folate equivalents, only methods 3 and 4 do not have interpretation problems (82).

The NCI method (79), developed at the National Cancer Institute, was also used for estimation of usual calcium and vitamin D (58) intakes, and intakes of a number of other vitamins and minerals (17,83, 84) for users (from the diet and supplement combined) and nonusers (from the diet) of dietary supplements. The average daily intake of nutrients from supplements was calculated for individuals using the number of days supplement use was reported, the reported amount taken per day, and the serving size unit from the product label. Calcium from antacids was also collected (58). The mean daily nutrient intake from supplements was added to the adjusted dietary intake estimates to obtain total usual nutrient intake. The amount-only part of the NCI method was used. The first step in the NCI method for nutrients (assumed to be consumed every day by every members of the population) replaces reported zero intakes with one-half of the minimum non-zero intakes value reported in the data set. The second step in the NCI method models Box-Cox-transformed 24h-recall observations as a function of observed fixed-effect covariates, unobserved individual-level random effects, and within-individual error. The covariates were: 1) sequence of the 24-h recall; 2) day of the week the 24-h recall was collected, dichotomized as weekend (Friday-Sunday) or weekday (Monday-Thursday); and 3) dietary supplement use. The first step in constructing the usual dietary intake distribution is to obtain a set of representative values whose empirical distribution approximates the assumed distribution of between-individual random effects. The NCI method uses a Monte Carlo simulation method to obtain a large set (by default, 100 estimates/ individual) of such values assuming the random effects are exactly normally distributed. Next, the covariate information in the data set is used to calculate 2 fixed effect predictions for each individual. The first of the 2 predictions is computed as if it were a first interview on a weekend day, the second is computed as it if were the first interview on a weekday. Other values of the covariates are held at their observed values for the individual. Corresponding representative value from the first step are added to each individual's 2 predictions and the resulting quantities are each back-transformed to the original scale using the procedure described by Dodd et al. (80). Next, the 2 original-scale predictions are combined in a weighted average giving weight 3/7 to the weekend prediction and 4/7 to the weekday prediction. The empirical distribution function of the resulting quantities, weighted according to the survey sampling weights, is an estimate of the usual dietary intake distribution. Finally, each individual's reported daily intake of the nutrient from supplement sources is added to his or her corresponding value(s) computed from the previous step and the empirical distribution of these final sums, weighted according to the survey sampling weights, is an estimate of the usual total intake distribution. SAS macros were used to fit this model and to perform the Monte Carlo-based estimation of usual intake distributions (85). All statistical analyzes were performed using SAS (version 9, SAS Institute) software. Sample weights were used to account for differential non-response and non-coverage and to adjust for planned oversampling of some groups. Mean usual dietary and total vitamin and mineral intakes were estimated and compared between supplement users and non-users and the proportion meeting the EAR and exceeding the UL.

The Carriquiry's method to combine nutrient intake from food and supplements was developed while the information about supplement use was collected as a part of one or two 24h recalls. Since distinguishing the non-consumers from the occasional consumers of supplements cannot be achieved with the information provided by the two independent 24-h recalls, a propensity questionnaire to complement the two 24-h recalls was proposed by Carriquiry as a practical and most effective solution. Bailey's method provides a relatively uncomplicated means to account for dietary supplement use in NHANES and could be applied to other than folate nutrients. Also, the method produces unbiased estimates of usual intake percentiles. When considering Garriguet's methods, method 1 significantly differs from other three, among which there is no statistically significant differences. The use of method 1 is not recommended for incorporating intake from supplements to dietary intake because several confidence intervals for the estimates of the prevalence of inadequacy fall outside the expected minimum-maximum value range. The NCI method represents advantages over previous methods in dietary assessment and combining intake from foods and supplements since it accounts for the correlation between probability of consumption a food and a supplement on a single day and amount consumed, and incorporates covariate information.

Chapter 3: Rationale

The role of nutrient intake in disease outcome is widely recognized. Thus, many studies are done in assessment of usual nutrient intake of populations, but most of them are based on food intake alone. However, it is vital to consider nutrient intakes from all sources, including dietary supplements as they can make important contributions to total nutrient intake. Failure to include all possible sources of nutrients produces errors in nutrient estimates, notable misclassification of individuals with regard to their total nutrient intake, and may impair the ability to detect associations between total nutrient intake and disease risk.

The 2004 Canadian Community Health Survey was the first since 1972 to study Canadians' eating habits. It evaluated total usual intake of several nutrients based on food and supplements consumption. Nevertheless, these studies didn't include the First Nations population living on reserve. The First Nations Food Nutrition and Environment Study (FNFNES) collected the information about the diet of First Nation people living on reserve with the purpose of monitoring the population's nutritional status. Based on this study, almost 30% of British Columbia and 13.2% of Manitoba First Nations have reported using at least one supplement during prior month. The prevalence of inadequate micronutrient intakes from diet plus supplements might be lower in individuals who use supplements than in ones who do not use supplements. From a public health perspective, it is important to understand whether individuals who take dietary supplements have a need for them (e.g., to avoid nutrient deficiencies) and whether dietary supplements can be used to meet nutrient requirements safely or if they contribute to risk of excess intakes.

Analyzing the FNFNES data, it was important to determine nutrients of greatest interest. According to the results released from the British Columbia FNFNES report, at least half of population, except older women, has inadequate intake of vitamin A (57-76%), vitamin C in smokers (75%), vitamin D (90-100%), and calcium (83-99%). Similarly, Manitoba FNFNES survey showed extremely low intakes of the following nutrients: vitamins A, C (particularly among smokers), D, and calcium. Thus, the prevalence of inadequate intake of vitamin A varied from 58 to 93%, vitamin D- 98-100%, vitamin C- 56-65%, (while among smokers-77-85%), and calcium- from 90 to 100%. For all other nutrients, the percentage of inadequacy was very low or was equal to zero. These data were based on food/beverages intakes only and did not consider the contribution of supplement consumption.

Therefore, the overall goal of this study is to integrate supplement use into dietary intake for the assessment of nutritional adequacy in British Columbia and Manitoba First Nations living on reserves and more specifically to calculate total usual intake of selected nutrients (vitamins A, C, D and calcium) for adult First Nations based on food/beverages and supplement consumption; and to evaluate the impact of dietary supplement use on nutrient adequacy.

Chapter 4: Methodology

4.1. Study design and subject selection.

This research is based on The British Columbia and Manitoba First Nations Food, Nutrition and Environment Study (FNFNES) database. FNFNES (26) is a 10-year study (2008-2017) aiming to assess the exposure to contaminants, diets and food security status of First Nations people living on reserves, south of the 60th parallel across Canada. This is a representative cross-sectional study which provides information needed for the promotion of healthy environments and healthy foods for First Nations. FNFNES is funded by Health Canada and led by the Assembly of First Nations (AFN), the University of Northern British Columbia and the Université de Montréal. To ensure that the diversity in ecozones* and cultural areas are represented in the sampling strategy, communities were sampled using a combined ecozone/culture area framework. All data presented in this report have been weighted accordingly.

*Ecozones are a classification scheme developed to differentiate the distribution of plants and animals. Culture areas are a classification scheme devised by anthropologists to assist in showing geographic areas of human communities that share similarities in cultural practices, such as subsistence, social and political organization, material culture, and so on. While sometimes criticized for overlooking important diversity within a region, the culture area concept has persisted in the social sciences as an organizing principle from which to undertake comparative studies.

British Columbia FNFNES was conducted in 21 randomly selected First Nations on-reserve communities during the fall 2008-2009. Communities (Primary Sampling Units or PSUs), households (Secondary Sampling Units or SSUs) and individuals (Tertiary Sampling Unit or TSU in each household), were selected using random mechanisms. In addition to the 19 randomly selected communities, two communities were added: Nuxalk Nation because of the existence of extensive dietary data to which the study results could be compared, and Skidegate (located on Haida Gwaii) was chosen due to its geographic isolation, cultural uniqueness (Haida is a language isolate) and lack of dietary or chemical contaminant data.

Individuals aged 19 years and over, self-identified as being a First Nation person living on reserve and able to provide written informed consent were invited to participate in the study. Data were collected from 1,103 participants; one participant per household (398 men and 705 women). The overall participation rate for completion of questionnaires was 68%. The average age of the participants was 46 years old for men and 44 years old for women (27).

Manitoba communities were selected according to the same sampling strategy as BC communities. A total of twelve communities were selected to participate in the study; however, only nine of them completed an adequate number of surveys in order to be included in the analysis. Thus, in Manitoba, data were collected from 9 randomly selected communities from September to December 2010. In each community, up to 100 households were randomly selected; one participant per household, aged 19 years and older, living on reserve and who self-identified as First Nation was invited to participate. There were a total of 706 participants (477 women and 229 men). The overall participation rate for questionnaires was 82%. The average age of the participants was 42 years old for women and 41 years old for men (28).

4.2. Inclusion and exclusion criteria.

Due to limited sample sizes, all participants aged 71years old and over were excluded from the BC and MA analyses. Pregnant and breastfeeding women were also excluded because of different nutrient requirements for these groups. Since nutrient requirements are the same for 19-30 and 31-50 age groups, these age groups were combined. Thus, 39 participants aged 71 and over (25 women, 14 men) and 44 pregnant and/or breastfeeding women were excluded from the BC analyses with the final sample of 1008 participants (627 females and 381 males). Similarly, the MA analyses did not include 24 individuals 71 and over age group (15 women and 9 men) and 19 pregnant and/or breastfeeding women. Thus, nutrient analysis was performed on a total of 658 subjects (438 females and 220 males).

4.3. Dietary intake data collection.

Dietary intake data were collected in person. All participants were asked to complete one 24-hour food recall, one-year traditional food frequency questionnaire, and a social, health, lifestyle, and food security questionnaire. To collect a 24 h recall, the multi-pass technique with 3 stages was used as follows: the first step was to make a quick list of all foods consumed during prior 24 hours; the second one was to do a detailed description of the consumed foods and beverages (brands, amounts, and amount eaten, etc..); and the third step was to review the recall with the participant to see if anything was missed. To estimate corresponding quantities of the intakes food and beverage models were used. A second 24-hr recall was filled by a subsample of 20% of the respondents to adjust for intra-individual variation using SIDE. This method allows for a better approximation of the usual diet.

4.4. Supplement intake data collection.

Information on vitamin and dietary supplement use was collected as a part of the Socio/Health/Lifestyle Questionnaire (Annex III). During the interview, all participants were first asked: “Yesterday, did you take any nutritional supplements, vitamins, minerals, or herbal, botanical or homeopathic preparations?” Then, this was followed by another question: “In the last month, did you take any other nutritional supplements, vitamins, minerals or herbal, botanical or homeopathic preparations?” Individuals who answered “yes” were classified as an overall dietary supplement user. After that, respondents were asked to get the supplement containers from which the drug identification number (DIN) or Natural Product Number (NPN), the product name, brand name and concentration of ingredients were obtained. In addition, the supplement users were asked to specify the amount (number of pills or tablets, capsules, teaspoons) usually taken on each occasion and frequency (per day, per week or per month) of supplement consumption. For individual nutrients, participants were classified as “users” for a particular nutrient if they took a supplement containing that nutrient; those who did not consume a supplement with a particular nutrient were classified as non-users of that particular nutrient.

The average daily intake of observed nutrients (vitamins A, C, D, and calcium) from dietary supplements was calculated for individuals using the number of days supplement use was reported, the reported amount taken per day, and the serving size unit from the product label. The composition of dietary supplements was identified from the December 2011 Licensed Natural Health Products Database (LNHPD) (100) when DIN/NPN and/or the correct product name and the brand name were available. However, many participants did not provide the requested product information. In fact, in Manitoba, the coverage of DINs of dietary supplements was 67% while in British Columbia these estimates were provided for only 45.4% of dietary supplements. In addition, some DINs were invalid, spelled out incorrectly, or there were no provided supplement and/or brand names. Sometimes, dietary supplements were reported as "multivitamin" without any additional detail. Then, it was difficult to identify the exact supplement consumed and the concentration of nutrients in the supplement. There was a need to make assumptions about the nutrient composition of a supplement based on the formulations of other similar products. In this case, the most commonly reported supplement in that class of supplements was used to represent the nutrient composition of the unknown supplement (see Appendix II).

4.5. Smoking status data collection.

The Socio/Health/Lifestyle (SHL) Questionnaire included questions on smoking status. All participants were asked whether they smoked cigarettes yesterday. If the answer was "yes", the following question was: "How many?" Participants who answered "no" were classified as "non-smokers" whereas individuals who answered "yes" were categorized as "smokers".

4.6. Estimation of the prevalence of inadequacy and percentage of intakes greater than the UL.

The prevalence of inadequacy and percent of intakes greater than the UL for all participants were calculated by gender and age group. The percent of inadequate dietary intakes of a group was determined using the estimated average requirement (EAR) cut-point method for selected nutrients (vitamins A, C, D, and calcium). The cut-point method requires more than one 24-hour dietary recall to adjust the dietary intakes for an individual to produce usual dietary intakes. The EAR cut-point method assumes that there is no correlation between intakes and requirements; the variance in intakes is greater than the variance of requirements; and the distribution of requirements is symmetrical around the EAR. When these assumptions are met, the number of individuals with usual intakes below the EAR is equal to the prevalence of the group with inadequate intakes.

4.7. Statistical analysis.

Incorporating supplement use to food and beverage intakes presents challenges. Garriguet's method 4 (82) was first attempted to analyse usual nutrient intake from food/beverages (measured by 24h recalls) and dietary supplements (collected through a 30-d questionnaire). Due to not enough sample size of the supplement users in certain age-gender-ecozone cellules, method 2 was used instead which includes:

1. Calculate usual individual dietary intake of the selected nutrient based on the two recalls using SIDE (101).
2. Using the SIDE output data set 'Smooth' generated from step 1, add the average intake of the selected nutrient from supplements. This creates a new variable which is the combined nutrient intake from dietary and supplement.
3. Calculate the total usual nutrient intake distribution ((SIDE output data set 'PCTU*') and percentage of the population with total intake of selected nutrient below or above a given threshold (SIDE output data set 'CDFU1*'), using SIDE on the new variable created from step 2.

During the process of the step 1, #65 error message (negative estimates for usual intake variance) occurred for some age group and some nutrients, in which case SIDE stop running and no output data set was generated. The centered fourth moment estimated from the higher level domain were forced by adding data sets PEVCR* and NPEVCR* and run

Step 1 again. These two values can be obtained from SIDE output data set VARCOMP*'s 4^{th} and 6^{th} observations. Once step1 is finished, no measurement errors were forced in step 3. Since step 3 is processed based on total usual individual intake which is better normalized data, there is no failing replicates among 500 runs. Therefore, the standard errors (SEs) are much smaller. In summary, the point estimates and SEs and Confidence intervals (CIs) are based on total usual individual nutrient intake and 500 bootstrap weights. For the sake of comparison of estimates with or without supplement intake, analyses of usual nutrient intake from food/beverages only were re-done using the above method by adding 0 as supplement intake. Comparisons of estimated prevalence of inadequacy obtained with and without incorporation of dietary supplements were done by comparisons of 95% confidence intervals (CI): estimates with overlapping CI being non-statistically significant (p>0.05).

PCTU*: percentiles for the usual intake distribution
CDFU1*: by default, the software prints the probabilities calculated with the estimated usual intake distribution that were specified in the CUTOFF dataset in the output window of SAS.
PEVCR*: SIDE dataset that instructs SIDE to force the within-individual variance and centered fourth moment to the specified amount.
NPEVCR*: SIDE dataset (used with PEVCR) that contains the relative weight that SIDE should use to determine when to force the variance from PEVCR (name =9999 instructs SIDE to give full weight to PEVCR and not to attempt to calculate the within-individual variance.
VARCOMP*: variance components for transformed daily intakes.

4.8. Ethical Approval.

Written informed consent of each participant was obtained before any data collection. Ethical approvals have been obtained from the Research Ethics Board of Health Canada, University of Northern British Columbia and Université de Montréal.

Chapter 5: Results

5.1. Prevalence of supplement consumption.

5.1.1. British Columbia

Table 5.1 shows the overall prevalence of dietary supplement use, prevalence of using supplements containing vitamins A, C, D, and calcium, and mean intake of selected nutrients from supplemental sources in BC. The proportions of BC participants, by gender and age groups, who took any type of supplements during the past month, are shown in Table 5.2. Figure 5.1 shows the percentage of supplement users consuming one, two, three and four nutritional supplements during a prior month by BC First Nation adults living on reserve.

In general, about 30% of British Columbia First Nation adults living on reserve reported the use of at least one dietary supplement including botanical and antacids within the prior month (Table 5.1). In regard to nutrients of interest, when supplements were categorised by ingredients, only 18.5% of participants reported vitamin D containing supplements, 18.2% - calcium containing supplements including antacids, 17.3% and 14.8% - supplements containing vitamin C and vitamin A, respectively. Among all supplement users (n=326), 57% took one supplement, 25% - two different supplements, 9% - three and four dietary supplements at the same time (Figure 5.1). The majority of users (83%) reported taking them every day within the last 30 days. Overall, the prevalence of use of any dietary supplement was higher among women than men in all age groups, especially among people aged 51 y and over (48% vs. 33%). The lowest prevalence of supplement consumption was reported by men aged 19-30 y (15%). Also, the use of dietary supplements increased with age for both genders. Thus, among female participants the percentage of supplement use varied from 21% to 48% while among male participants the prevalence of supplement intake varied from 15% to 33% (Table 5.2). Multivitamin-multimineral supplements for adults was the most frequently consumed dietary supplements (18%) while vitamin D (10%), vitamin C (8%), and calcium (8%) were the most commonly reported single vitamin or mineral supplements (data not shown).

The overall mean intakes of vitamins A, C, D, and calcium from supplemental sources varied by age and gender groups (Table 5.1). In British Columbia, despite the higher prevalence of supplement use among females compared to males, mean intakes of vitamins A and D from supplements were lower in younger women than younger men. Thus, in female supplement users aged 19-50 y mean intake of vitamin A was 985µgRE whereas in male supplement users of the same age group mean intake of vitamin A was 1324µgRE. Similarly, the lowest mean intake of vitamin D from supplements was observed in women aged 19-50years and was 14µg compared to 17.8µg in men aged 19-50y. In contrast, mean vitamin C and calcium intakes from supplemental sources observed to be dramatically higher among women of all age groups compared to men. Interestingly, mean intake of calcium from dietary supplements increased with age for both women and men while mean intake of vitamin C decreased with age for both genders (Table 5.1)

Table 5.1: Prevalence of any dietary supplement use and supplements containing only vitamin A, C, D, and calcium, and mean intake from supplements by gender and age groups among BC First Nations living on reserve.

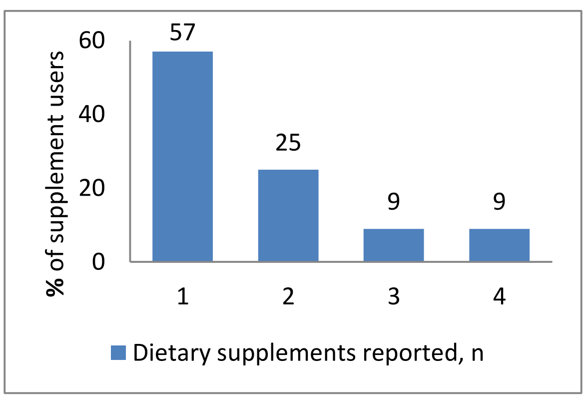
	Use of any supplements including v.A,C,D, &CA	**Vitamin A (µgRE)**	**Vitamin C mg**	**Vitamin D µg**	**Calcium mg**
Supplement use (%)	**29.6%**	**14.8%**	**17.3%**	**18.5%**	**18.2%**
Mean intake from supplements (SD)	**overall**	1236 (1326)	249 (599)	16.3 (11.1)	478 (392)
	Women				
	19-50	985(1139)	307 (801)	14.0 (8.2)	465 (427)
	51-70	1504 (1476)	193 (228)	18.5 (14.8)	582 (405)
	Men				
	19-50	1324 (1406)	189 (157)	17.8 (10.2)	340 (218)
	51-70	1482 (1347)	166 (171)	17.7 (8.2)	414 (315)

SD- standard deviation

Table 5.2. Prevalence of dietary supplement use by gender and age groups among British Columbia First Nations living on-reserve (n-total).

Sex	Age group	Percent of participants (1103) % (n)
women	19-30	21 (40)
	31-50	34 (110)
	51 & over	48 (91)
men	19-30	15 (8)
	31-50	29 (34)
	51 & over	33 (39)

Figure 5.1. Percentage of supplement users consuming one, two, three and four nutritional supplements during a prior month by British Columbia First Nation adults living on reserve.



5.1.2. Manitoba.

Overall prevalence of dietary supplement use, prevalence of using vitamins A, C, D, and calcium supplements, and mean intake of selected nutrients from supplemental sources in MA are shown in Table 5.3. Table 5.4 shows the proportions of MA participants, by gender and age groups, who took any type of supplements during the past month. Figure 5.2 shows the percentage of supplement users consuming one, two, three and four nutritional supplements during a prior month by Manitoba First Nation adults living on reserve.

The prevalence of supplement consumption in Manitoba First Nations living on reserve greatly differed from that in British Columbia (Table 5.3). Thus, only 13.2% of First Nation adults aged 19 y and older reported use of any dietary supplement including botanical supplements and antacids during prior 30 days. In regard to selected nutrients, only 8% of participants reported intake of supplements containing vitamin D, 7.3% - calcium, 5% - vitamin C, and less than 5% -vitamin A. The majority of supplement users (70%) took only one supplement while 18% - two supplements, 11%- reported taking three and only one person took four different supplements in the prior month (Figure 5.2). Nearly 77% of all users (n=93) reported consumption of dietary supplements on a daily basis. The use of nutritional supplements was observed to be higher in older participants aged 51 and over (especially among males 16 vs. 21%) compared to the younger age groups (up to11%). Surprisingly, among men aged 19-30 y the prevalence of supplement consumption was equal to zero (Table 5.4). Among all dietary supplement, the most commonly used type of supplement was calcium (20%) followed by MVMM supplements for adults (17.7%) and vitamin D (12%) (data not shown).

In Manitoba First Nations, the mean intakes of all key nutrients from supplemental sources were much lower than those in British Columbia participants (Table 5.3). This may be explained by the lower prevalence of supplement consumption among Manitoba participants compared to BC ones (13% vs. 30%, respectively). The greatest difference in mean intakes was observed for vitamin A in men aged 51-70 y (BC - 1482µgRE vs. Manitoba - 465µgRE). In Manitoba, as was noted previously, the percentage of supplement use among older males (51 and over) was higher than among female. Nevertheless, the mean intakes of all selected nutrients from supplemental sources in men of this age group were significant lower than those in females of the same age group. However, younger men aged 19-50 y had higher mean intake of all selected nutrients than older men except calcium. Among all Manitoba supplement users, the highest mean intake from supplements was observed in women aged 51-70 y for all selected nutrients: 1050µgRE of vitamin A, 259mg of vitamin C, 17.3µg of vitamin D, and 548mg of calcium. The lowest intakes of vitamin A was found in male users of dietary supplements aged 51-70y (465 µgRE), of vitamins C (61mg) and D (8.5µg) – among female users 19-50 y, and of calcium – among males 19-50 y old (212mg) (Table 5.3).

Table 5.3. Prevalence of any dietary supplement use and supplements containing only vitamin A, C, D, and calcium, and mean intake from supplements by gender and age groups among MA First Nations living on reserve.

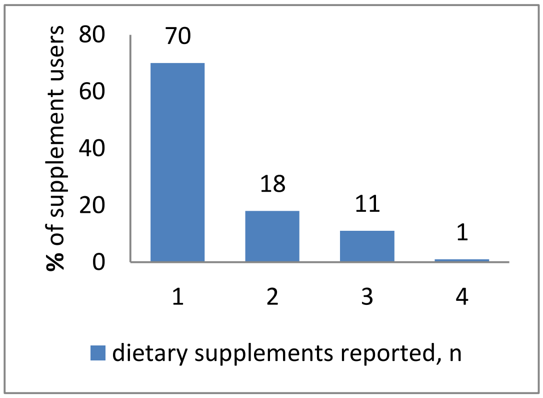
	Use of any supplements including v.A,C,D &Calcium	Vitamin A (µgRE)	Vitamin C mg	Vitamin D µg	Calcium mg
Supplement use (%)	**13.2%**	**4.9%**	**5.0%**	**8.1%**	**7.3%**
Mean intake from supplements (SD)	**overall**	798 (577)	119 (179)	11.5 (8.3)	405 (334)
	Women				
	19-50	854 (775)	61 (39)	8.5 (6.2)	362 (279)
	51-70	1050 (232)	259 (333)	17.3 (9.1)	548 (332)
	Men				
	19-50	818 (480)	93 (60)	10.3 (6.4)	212 (132)
	51-70	465 (448)	80 (83)	9.8 (9.1)	312 (422)

SD- standard deviation.

Table 5.4. Prevalence of dietary supplement use by gender and age groups among Manitoba's First Nations living on-reserve (n-total).

Sex	Age group	Percent of participants (705) % (n)
women	19-30	11 (13)
	31-50	11 (34)
	51 & over	16 (24)
men	19-30	0 (2)
	31-50	10 (8)
	51 & over	21 (12)

Figure 5.2. Percentage of supplement users consuming one, two, three and four nutritional supplements during the prior month by Manitoba First Nation adults living on reserve.



5.2. Mean intakes and the prevalence of intakes below the EAR of selected nutrients from food sources only and food plus supplements.

5.2.1. British Columbia

Tables 5.5 and 5.6 show mean intakes and the prevalence of intakes below the EAR of key nutrients from food and food plus supplements by gender and age groups in BC participants. Table 5.7 shows mean vitamin C intakes and the prevalence of intakes below the EAR by smoking status in BC.

5.2.1.1. Mean intakes of selected nutrients from food and food + dietary supplements.

In British Columbia First Nation participants, the intake of dietary supplements did not dramatically contribute to usual mean intakes with the exception of vitamins A, and C in participants aged 51-70 y. Mean intakes of vitamins A and C from food alone were higher than the recommended (EAR) across all age groups except males aged 51-70 y for vitamin A only. When intakes from dietary supplements were included, the mean vitamins A and C intakes were further increased and even more than doubled in some age groups for vitamin C. Dietary supplement use particularly increased mean intakes of vitamin D and calcium in all age/sex groups, but in no case this changed the mean intakes from below the EARs to at or above the EARs with the exception of women aged 51-70 y for calcium (Table 5.5).

Table 5.5. Mean intake of selected nutrients from food and food + supplements by sex and age group in British Columbia First Nations living on-reserve.

Sex	Age group	N	Mean intake/ EAR	vit.A (µgRE/ day)	vit. C (mg/day)	vit. D (µg/day)	Calcium (mg/day)
Males	**19-50**	**240**	**Food sources only**	643 (27)	111 (4)	6.3 (0.4)	591 (14)
			Food sources +supplements	721 (28)	129 (8)	8.1 (1.1)	624 (10)
			EAR	625	75	10	800
	51-70	**141**	**Food sources only**	503 (21)	125 (27)	6.5 (0.2)	540 (36)
			Food sources +supplements	903 (265)	154 (26)	9.9 (0.8)	649 (32)
			EAR	625	75	10	800
Females	**19-50**	**456**	**Food sources only**	529 (27)	86 (6)	4.3 (0.2)	548 (7)
			Food sources +supplements	622 (32)	151 (16)	6.3 (0.4)	615 (15)
			EAR	500	60	10	800
	51-70	**171**	**Food sources only**	591 (31)	100 (6)	6.0 (0.2)	544 (21)
			Food sources +supplements	848 (62)	161 (19)	10.7 (1.8)	707 (42)
			EAR	500	60	10	1000

5.2.1.2. Prevalence of inadequate intake from food sources only.

In British Columbia, the percentage of nutrient intakes below the EARs from food sources alone varied by micronutrient, age group and gender (Table 5.6). Overall, micronutrient intakes from diet only were very low for all nutrients except vitamin C. In fact, the prevalence of vitamin C intake below the EAR was the lowest among all key nutrients and, depending on age and gender group, varied from 18% to 43.6%. The highest prevalence of intake below the EAR was observed for vitamin D varying from 93% to 100%, and for calcium varying from 91% to 99%. Particularly, men aged 19-50 y had the lowest prevalence of vitamin D intake below the EAR (93%) and women aged 19-50 y had the lowest prevalence of calcium intake below the EAR (90%) from diet alone. In general, the percentage of vitamin A intakes below the EAR among BC First Nation adults was lower than those of vitamin D and calcium and varied from 34% to 77%. Among all males, those aged 19-50 y had higher prevalence meeting the recommendations of selected micronutrients from food only compared to men aged 51-70 y, except calcium. In contrast, females aged 51-70 y had lower percentage of vitamins A and C intakes below the EAR from food alone compared to females aged 19-50 y; however, they had slightly higher prevalence of calcium intake below recommended (99% vs. 91%) and almost equal value of vitamin D intake below the EAR (100%) (Table 5.6).

Table 5.6. Prevalence of nutrient intakes below the recommended levels from food and food +supplements by gender and age groups among BC First Nation supplement users and non-users living on reserve.

Nutrient		**%< EAR (95% CI)**			
		males		**females**	
		19-50	**51-70**	**19-50**	**51-70**
		n=240	**n=141**	**n=456**	**n=171**
Vit. A	**food**	52.5 (41.8-66.7)	77.1 (69.3-96.9)	60.5 (55.4-64.9)	34.1 (15.2-51.9)
	Food/supplem	43.6 (25.9-54.5)	64.3 (31.2-77.7)	53.8 (48.3-61.7)	25.3 (14.2-28)
Vit. C	**food**	18.4 (9.7-30.3)	36.5 (19.6-55.6)	43.6 (34.4-49.9)	17.8 (10.5-26.1)
	Food/supplem	17.8 (7.8-28.8)	31.4 (15.2-51.9)	31.1 (21.9-35.5)	10.3 (4.0-20.3)
Vit. D	**food**	92.6 (85.4-97.4)	95.5 (92.4-100)	100.0 (99.8-100)	99.0 (97.4-100)
	Food/supplem	81.3 (64.9-92.6)	75.6 (63.2-88.2)	87.3 (83.8-91.8)	76.3 (57.0-93.0)
calcium	**food**	94.5 (90.6-99.1)	92.9 (87.3-100)	90.8 (85.6-97.6)	99.0 (98.6-100)
	Food/supplem	88.6 (85.6-95.4)	75.5 (68.1-96.0)	82.9 (75.9-87.0)	87.3 (80.5-93.1)

5.2.1.3. Prevalence of inadequate total intakes (diet and supplements combined).

The use of dietary supplements lowered the prevalence below the recommended for each examined nutrient to different degrees (Table 5.6). The greatest contribution was observed for vitamin D in older participants. In fact, in men aged 51-70 years old the percentage of inadequate intake was reduced from 95.5 % to 75.6% (20 percentage points) while in women of the same age group the percentage below the EAR was decreased from 99% to 76.3% (23 percentage points). In younger men and women aged 19-50 years old the use of vitamin D containing supplements lowered the prevalence of intake below the recommended from 92.6% to 81.3% and from 100% to 87.3%, respectively. The use of vitamin A containing supplements increased meeting the EAR by about 7-13 percentage points in different age and sex groups. The highest prevalence of vitamin A intake below the EAR was among men 51-70 year old (64.3%). Calcium containing supplements lowered the prevalence of intakes below the recommended by about 6-12 percentage points leaving 76-87% below the EAR in different age/ gender groups. The greatest impact of vitamin C supplements on total nutrient intakes was observed in women aged 19-50 y (from 43.6% to 31.1%) whereas the lowest impact was among 19-50 y-old men (less than 1%) (Table 5.6).

5.2.1.4. Prevalence of vitamin C inadequate intake among smokers and non-smokers.

In British Columbia, mean vitamin C intakes from food alone were below the EAR only among smokers, both female and male (Table 5.7). However, after considering use of dietary supplements mean intake of vitamin C was above the recommended level in all participants. The greatest contribution of vitamin C from supplements was observed in female non-smokers (74mg).

In male aged 19 y and over, when only food and beverages were considered, the prevalence of vitamin C intake below the EAR was as much as twice higher among smokers (n=179, 67.3%) compared to non-smokers (n=202, 33.9%). Dietary supplements use lowered the prevalence below the EAR in smokers by almost 14 percentage points whereas among non-smokers- by only 3.4 percentage points. The highest prevalence of vitamin C intake below the recommended was found in female smokers (n=295) reaching 72.3% when only diet was considered and 58.6% when food and dietary supplements were combined. Among female non-smokers (332) aged 19 y and over, the prevalence of intake below the recommended was about 20% (food alone) and 14.3% (food +supplements) which was the lowest value among all groups (Table 5.7).

Table 5.7. Mean ±SE vitamin C intakes, and prevalence of inadequacy among smoker and non-smoker First Nation adults living on reserve (British Columbia).

Sex/age group	Smoking status	N	EAR	Food/beverage only		Food/beverage + supplements	
				Mean (SE)	%<EAR (95% CI)	Mean (SE)	%<EAR (95% CI)
Males 19+	Non-smoker	202	75	117 (11)	34 (9-45)	137 (10)	31 (8-43)
	Smoker	179	110	104 (4)	67 (56-74)	129 (18)	54 (24-65)
Females 19+	Non-smoker	332	60	98 (5)	20 (13-23)	172 (25)	14 (8-20)
	Smoker	295	95	75 (8)	72 (58-90)	122 (20)	59 (52-67)

5.2.2. Manitoba

Tables 5.8 and 5.9 show mean intakes and the prevalence of intakes below the EAR of key nutrients from food and food plus supplements by gender and age groups in MA participants. Table 5.10 shows mean vitamin C intakes and the prevalence of intakes below the EAR by smoking status in MA.

5.2.2.1. Mean intakes of selected nutrients from food and food + dietary supplements.

In Manitoba participants (Table 5.8), the contribution of supplements to total usual mean intakes was much more negligible than in British Columbia varying from 23 to 43 µgRE of vitamin A, 2-11 mg of vitamin C, 0.5-1.4 µg of vitamin D, and 7-69 mg of calcium across different age and gender groups. The lowest usual mean intake from diet alone was observed for vitamin D in all age groups. Even when intake from vitamin D containing supplements was included, total usual mean intake was almost or more than twice as lower as recommended in all participants. Similarly, mean intakes of vitamin A and calcium from dietary source were much lower than the recommended. Only mean intakes of vitamin C met or was higher than the EAR in all age groups except men aged 51-70 y (66mg while EAR is 75mg) (Table 5.8).

Table 5.8. Mean intake of selected nutrients from food and food + supplements by sex and age group in Manitoba First Nations living on-reserve.

Sex	Age group	N	Mean intake (SE)/EAR	vit.A (µgRE/ day)	vit. C (mg/day)	vit. D (µg/day)	Calcium (mg/day)
Males	**19-50**	**163**	**Food sources only**	434 (18)	79 (2)	5.0 (0.2)	690 (32)
			Food sources +supplement	472 (43)	84 (3)	5.5 (0.5)	697 (32)
			EAR	625	75	10	800
	51-70	**57**	**Food sources only**	458 (62)	60 (3)	4.5 (0.3)	510 (48)
			Food sources +supplement	501 (72)	66 (8)	5.9 (1.1)	548 (91)
			EAR	625	75	10	800
Females	**19-50**	**324**	**Food sources only**	317 (12)	71 (1)	3.8 (0.2)	535 (7)
			Food sources +supplement	344 (17)	73 (1)	4.4 (0.3)	559 (12)
			EAR	500	60	10	800
	51-70	**114**	**Food sources only**	431 (19)	61 (4)	3.2 (0.1)	503 (17)
			Food sources +supplement	454 (28)	72 (11)	4.4 (0.5)	572 (45)
			EAR	500	60	10	1000

5.2.2.2. Prevalence of inadequate intakes from food sources only.

In Manitoba (Table 5.9), the prevalence of nutrient intakes below the EAR from food sources alone was even greater than those in British Columbia. The most notable prevalence of intake below the recommended was observed for vitamin D intake and was almost 100% for Manitoba. Similarly, calcium intake below the EAR was greater than 90% in all age/gender groups except men aged 19-50 y with the value of about 74% below the EAR. Regarding vitamin A, the prevalence of intake below the recommended in Manitoba First Nations was much higher than that in British Columbia's, especially in younger men and women aged 19-50 y where the value goes up to 92-96% < the EAR. However, no significant differences were observed among Manitoba male and female participants aged 51-70 y in term of vitamin A intake below the EAR (73.4-75%). In regard to vitamin C, the percentage below the EAR was also higher in Manitoba males and females varying from 48% to 65% than in British Columbia participants (18-44%). However, only 2.7% of women aged 19-50 y had intakes below the EAR for vitamin C from food sources only. As we see, the prevalence of nutrient intakes below the EARs from diet only was very high among all Manitoba First Nation adults except women of 19-50 y in term of vitamin C (Table 5.9).

Table 5.9. Prevalence of nutrient intakes below the recommended levels from food and food +supplements by gender and age groups among MA First Nation supplement users and non-users living on reserve.

Nutrient		%< EAR (95% CI)			
		males		females	
		19-50	51-70	19-50	51-70
		n=163	n=57	n=324	n=114
Vit. A	food	96.2 (93.8-98.8)	73.4 (70.5-94.7)	92.4 (88.2-96.6)	75.1 (63.1-90.5)
	Food/supplem	91.2 (82.8-98.7)	70.8 (68.4-93.4)	88.3 (83.7-94.7)	74.9 (56.6-90.4)
Vit. C	food	48.2 (36.7-55.0)	65.2 (64.1-95.4)	2.7 (0.4-5.3)	61.2 (49.5-74.0)
	Food/supplem	46.4 (32.1-50.6)	63.4 (52.3-83.0)	2.7 (0.6-4.3)	58.6 (44.0-71.5)
Vit. D	food	98.8 (97-100.0)	100.0 (98.4-100.0)	98.0 (95.7-100.0)	100.0 (100-100.0)
	Food/supplem	93.1 (89.6-98.6)	92.4 (76.7-100.0)	93.2 (81.5-96.5)	94.0 (91.0-99.2)
calcium	food	74.4 (57.5-83.8)	89.5 (86.2-96.2)	100.0 (99.9-100.0)	100.0 (99.8-100.0)
	Food/supplem	74.5 (57.6-82.7)	84.8 (69.4-95.5)	96.1 (93.0-98.6)	92.6 (87.0-99.8)

5.2.2.3. Prevalence of inadequate total intakes (diet and supplements combined).

In Manitoba, the contribution of dietary supplements to total intake of vitamins A, C, D, and calcium varied from 0 to 7 percentage points across all age groups (Table 5.9). After considering supplement use, the highest prevalence of intakes below the EAR was observed for vitamin D (92-94%) and calcium (85-96%) except 19-50 y-old men (75%). Similarly, vitamin A supplements only slightly contributed to total nutrient intakes leaving 71-91% below the EAR. Interestingly, male and female participants aged 51-70 y had notably lower percentage of vitamin A intakes below the recommended levels (with and without supplements) than those aged 19-50 y. In contrast to other nutrients, a higher proportion of the Manitoba population met the recommendations for vitamin C intake (with and without dietary supplements). Particularly, about 97% of women aged 19-50 y had adequate intake of vitamin C (Table 5.9).

5.2.2.4. Prevalence of vitamin C inadequate intake among smokers and non-smokers.

In regard to smoking status (Table 5.10), the prevalence of vitamin C intake below the EAR was higher than that in British Columbia except among non-smoker women (about 10% below the EAR). In addition, supplement use was associated with negligible reductions in the prevalence of vitamin C intake below the recommended in both males and females varying from only 0 to 4 percentage points. Thus, in smoker men, the percentage of vitamin C intake below the EAR was nearly 92% and in smoker women - 81% when intake from food and supplements were combined. The total usual mean intake of vitamin C, even when contribution from supplements was considered, was lower than the recommended level in all participants with the exception of non-smoker females (70 mg when EAR-60mg). About 66% of non-smoker men had intake of vitamin C below the EAR.

Table 5.10. Mean ±SE vitamin C intakes, and prevalence of inadequacy among smoker and non-smoker First Nation adults living on reserve (Manitoba).

Sex/age group	Smoking status	N	EAR	Food/beverage only		Food/beverage + supplements	
				Mean (SE)	%<EAR (95% CI)	Mean (SE)	%<EAR (95% CI)
Males 19+	Non-smoker	93	75	66 (11)	70 (55-78)	74 (12)	66 (53-80)
	Smoker	136	110	76 (2)	94 (93-99)	78 (4)	92 (89-98)
Females 19+	Non-smoker	166	60	66 (0)	10 (2-19)	70 (3)	10 (3-19)
	Smoker	288	95	70 (5)	83 (76-91)	75 (7)	81 (72-89)

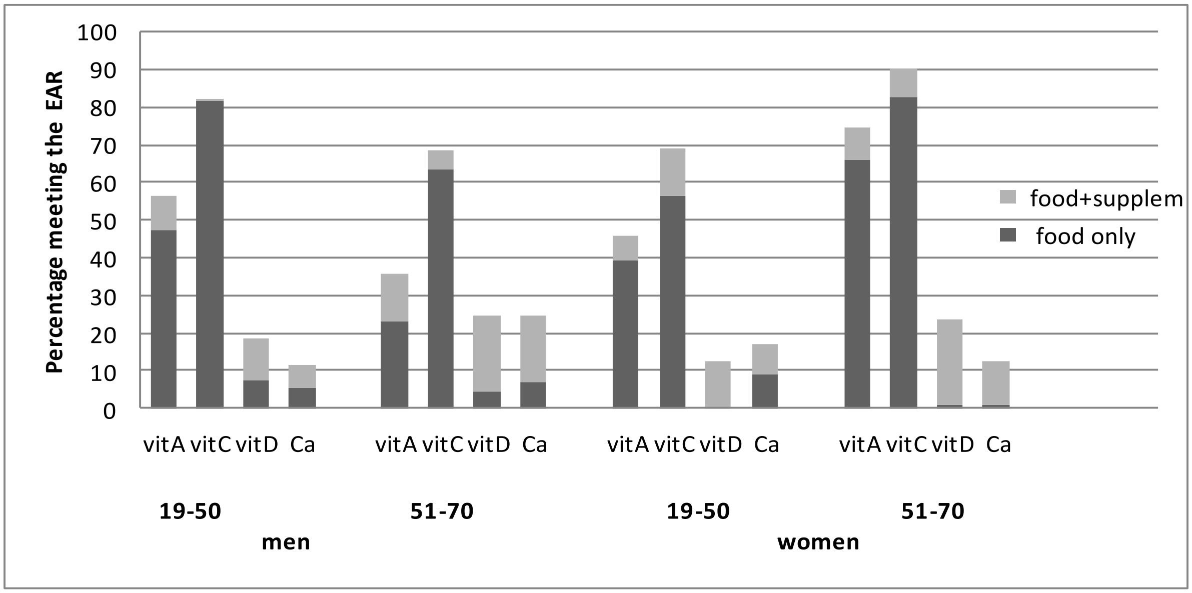
5.3. The prevalence of intakes above the UL.

The nutrient intake from food alone was not sufficient to exceed the Tolerable Upper Intake Level (UL) for any of selected nutrients in this analysis in BC and MA. When contribution of supplement use was included, only few people exceeded the UL for nutrients of interest. In British Columbia, the prevalence of intakes exceeding the UL was 0.1% for vitamin C in female and for calcium among males and females aged 51-70 y (0.3% and 1.3%, respectively). In Manitoba First Nation participants, regardless of supplement consumption, no person exceeded the UL for any of examined nutrients (data not shown).

5.4. Summary results.

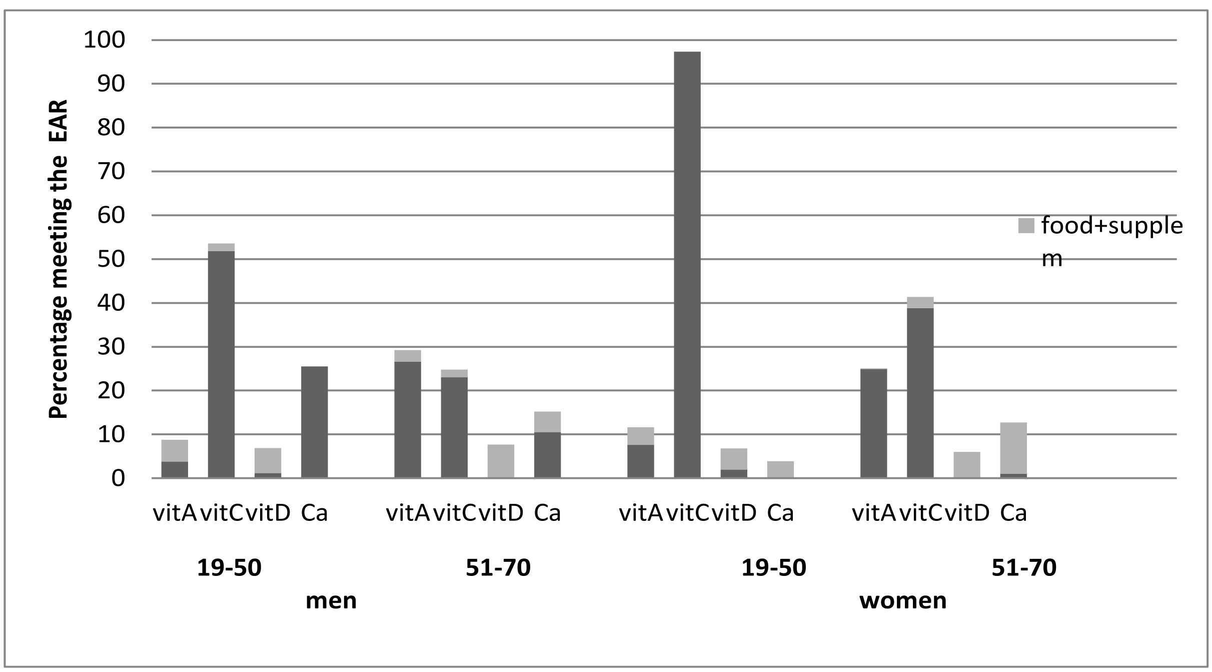
Figures 5.3 and 5.4 show the percentage of the populations meeting the EARs for examined nutrients in BC and MA. The highest prevalence meeting the EAR was observed for vitamin C in both provinces varying in different age/gender groups from 70 to 90% in BC and from 25 to 97% in MA when food and supplement use were considered. The percentage meeting vitamin A requirements was higher in BC than in MA. Thus, varying from 36 to 75% of BC First Nations and only from 9 to 30% of MA participants met the vitamin A recommendations from food and dietary supplements. Vitamin D and calcium intakes were very low in both provinces. Thus, less than 25% of BC and MA participants met recommendations for vitamin D and calcium. Furthermore, many of the participants who did meet the EARs for vitamin D and calcium did so only because of supplement consumption. Percentage meeting the EAR is less than 50% for most nutrients.

Figure 5.3. Percentage meeting the EAR for vitamin A, C, D, and calcium from food and food plus supplements, by age group and gender in British Columbia



Statistically significant difference ($p<0.05$) for vit.D in males and females aged 51-70y and Ca – in females aged 51-70y.

Figure 5.4. Percentage meeting the EAR for vitamin A, C, D, and calcium from food and food plus supplements, by age group and gender in Manitoba



No statistical difference ($p>0.05$) between estimates of inadequacy obtained with or without incorporation of dietary supplements

Chapter 6: Discussion

6.1. Main findings.

To our knowledge, this is the first effort to calculate and describe total usual dietary intake including dietary supplements and antacids in First Nations population living in Canada. Before this report, only few studies reported overall prevalence of dietary supplement consumption; however, they did not integrate them into total usual intake (6,7,8,9,10,11,99). According to this study, about 30% of British Columbia and only 13.2% of Manitoba First Nation people aged 19-70 y living on reserve reported use at least one dietary supplement within the prior 30 days. However, when considering nutrients of interest, a smaller percentage of the populations took them varying from nutrient to nutrient from 14.8 to 18.5% in British Columbia and from 4.9 to 8% in Manitoba population. The majority of participants from both provinces who reported dietary supplements used them on a daily basis. Multivitamin-multimineral supplements were the most common type of used dietary supplements in British Columbia whereas calcium was the most frequently reported by Manitoba participants. When supplements were categorised by ingredients, vitamin D and calcium containing supplements were consumed more frequently compared to those containing other examined nutrients (vitamins A and C) in both provinces. Overall, the prevalence of use of any dietary supplement was higher among women than men in all age groups and increased with age in both genders. Thus, almost half of British Columbia older women reported dietary supplement use in the prior month. However, among Manitoba participants, slightly more men than women aged 51 and older reported consumption of dietary supplements while no man aged 19-30 y took them.

The mean nutrient intake from supplements was found to be higher in women than men, and in older age group compared to younger. Despite the substantial mean intakes of examined nutrients from dietary supplements (especially among British Columbia participants), the overall effect of supplements was however relatively modest.

The highest prevalence of intakes below the EARs from food sources alone was observed for vitamin D and calcium in both British Columbia and Manitoba varying from 90 to 100% except among younger men with the prevalence of calcium intake below the EAR of 74.5%. The percentage of vitamin A intake below the recommended was more prevalent in Manitoba than British Columbia and varied from 73 to 96% and 34 to 77% in different age/gender groups, respectively. Among all examined nutrients, the lowest prevalence of inadequate intake was found for vitamin C in both provinces. In Manitoba, younger participants had higher vitamin C intake than older ones. Furthermore, about 97% of young women aged 19-50 y met the EAR for vitamin C from food sources only.

When the nutrients from supplements were considered, no significant reduction in prevalence of micronutrient intake below the recommended levels was observed among participants from both provinces. This may be because the majority of participants did not take any dietary supplements and those who did take them tended to already have adequate dietary intake of micronutrients. The greatest contribution of supplements was found for vitamin D and calcium, especially among British Columbia older women and men (7-23 percentage points) reducing the prevalence below the EAR from 96-99% to about 76%. Nevertheless, even after considering use of dietary supplements, more than three fourth of participants failed to meet the EAR for these nutrients. In Manitoba First Nations, an even smaller contribution (0-7 percentage points) of nutrients from supplemental sources was observed. Vitamin C was the only micronutrient with the lowest percentage of BC and MA participants bellow the EAR with and/or without supplements consumption.

Similarly to negligible effect on the prevalence of nutrient inadequacy, dietary supplement use only slightly contributed to usual mean intake of selected nutrients, especially of vitamin D and calcium, in both provinces. However, mean intake of vitamin C from food sources in the British Columbia population was dramatically higher than that of other nutrients. Similarly in the Manitoba population, mean vitamin C intake from food alone was equal to or exceeded the EAR. As we see, baseline dietary intake of vitamin C is relatively high in both populations. When including supplemental sources of nutrients, mean intakes of vitamin C were much higher that the recommended in all age/gender groups in both British Columbia and Manitoba. This contribution of vitamin C intake could be explained by the fact that the amount of vitamin C in multivitamin-multimineral supplements is high in relation to the amount needed to meet the RDA. For other examined nutrients in Manitoba (vitamins A, D, and calcium), the mean intakes from all sources including dietary supplements were much lower than recommended. In regard to smoking status, the impact of vitamin C supplements consumption was greater in smokers compared to non-smokers, particularly in British Columbia population, and was almost a 14-percentage-point reduction among both men and women. Even though smokers have greater vitamin C requirements compared to non-smokers, it seems that they did consume more vitamin C from supplements than non-smokers. Manitoba male and female smokers had higher mean vitamin C intakes from food only than non-smokers.

Overall, supplement use had little impact on the prevalence of inadequate nutrient intakes in both provinces. This may be explained by low prevalence of dietary supplement consumption; small amount of selected nutrients in MVMM supplements (except vitamin C), and the fact that people who reported taking dietary supplements were more likely to already get adequate intake of these nutrients from food alone. Among all supplement users from both provinces, almost nobody was exceeding the UL.

6.2. Comparing of the study results to previous research.

We could not directly compare our finding to the NHANES and CCHS data because of the following reasons. First, many reports based on the US and Canadian surveys have examined nutrient intakes from diet alone and from diet plus supplements as well as the prevalence of nutrient inadequacy after splitting the population on supplement users and non-users. However, due to the small sample sizes of supplement users in BC and Manitoba populations, we could not divide them into two groups. Next, most previous reports analysed vitamin D and calcium intakes using the AI instead of updated EAR for these nutrients. Finally, because of relatively small sample sizes of participants in each age group, we used different age grouping as used in some other studies.

NHANES 2003-2006 (32) showed that dietary supplement use among adult Americans was about 54%, and the most recent NHANES 2007-2008 study (59) suggested that nearly 50% of U.S. adults reported taking of dietary supplements. Similarly, Guo et al (24) reported that about 40% of all adult Canadians consumed dietary supplements. In contrast to these data, Canadian Aboriginal populations showed much lower prevalence of supplement use (30% of BC and 13% of Manitoba First Nation adults). In addition to that, no previous study has observed such high prevalence of vitamins A, D and calcium intakes below the EARs neither from diet only nor from diet plus supplement use that reached up to 90-96% in BC and Manitoba participants.

However, similar to the reports from American and Canadian national surveys, our finding show that the prevalence of dietary supplement use was higher among women compared to men and gradually increased with age (17,20,59,73,83). Also, MVMM supplements were the most frequently reported dietary supplement. In addition, our results are consistent with Murphy et al (16), Garriguet (18), and Kennedy et al (59) regarding the observation that people who used dietary supplements tended to already have adequate or close to adequate nutrient intake from food alone compared to non-users. Conversely, people at higher risk for nutrient inadequacy were less likely to report dietary supplement use. This suggests that people interested in nutrition generally use supplements as one means of improving their nutrient intake. Similar to our findings, Shakur et al (73) concluded that vitamin A, D, and calcium are nutrients of greater concern among Canadian adults. In our study, calcium intake from supplements was slightly higher among women than men especially those aged 51-70 years old; however, in general, men had higher calcium intake which was primarily derived from their diets. These findings are consistent with those from the Vatanparast et al report (23).

6.3. Strengths and limitations

The main strength of this study is that we have a representative survey of all British Columbia and Manitoba First Nation adults living on reserve (with the exception of one ecozone in MA). Furthermore, this survey is the first to represent estimates of nutrients from diet and dietary supplements including antacids in Canadian First Nations, which is necessary for the accurate and precise estimation of total usual intake. Next, the overall response rate for completion of questionnaires was relatively high (68% in British Columbia and 82% in Manitoba). An additional strength of the study is that supplement data were collected directly from supplement containers, when available, by a trained interviewer during in-person household interview. Finally, this study reports prevalence of inadequacies for vitamin D and calcium, using the updated EAR for these nutrients.

Our main challenge lied in the combining of two sources in estimating a distribution of total nutrient intake. The data from food intake were measured by two 24h recalls and dietary supplements data were collected through a 30-d frequency questionnaire. Morover, the reference period of 24-h recall data differed from that of the supplements data. As a result, nutrient estimates from two instruments may not be directly comparable. Garriguet's method 4 (82) was intended to combine usual nutrient intake from food/beverages and dietary supplements. However, because of inadequate sample size of supplement users in some sex-age groups, Garriguet's method 2 (82) was used instead to combine two sources of nutrients. Since Method 4 is based on the original Methods 2, there are no statistically significant differences however between these methods.

To identify the composition of dietary supplements Drug Products Database (DPD) approved by Health Canada was used. However, the coverage of supplements specifications was different in two populations. According to this analysis, approximately 45% of dietary supplements reported by British Columbia participants and 67% of those reported by Manitoba First Nations were provided with Drug Identification Numbers

(DINs). However, some of the reported supplement DINs were not found in the database. This is because product formulation frequently changes over time, new supplements often become available, while others are discontinued and taken off the market. In addition to that, some participants did not provide the requested product information or the information was inadequate (DINs were invalid, spelled out incorrectly, or there were no provided supplement and/or brand names, etc.). In case where the exact formulation of the supplements could not be determined, a set of default values based on the most commonly reported type and/or amount of supplements was used to represent the nutrient composition of the unknown supplements.

For instance, several reported dietary supplements, named as “multivitamins”, were not provided with additional information. To match these products in the BC and MA supplement composition table (SCT), the frequency of every reported brand of the multivitamins were calculated to find out the most frequently used brand of multivitamins. Among all reported multivitamins, Centrum was the most frequently reported in both BC and MA. Thus, Centrum multivitamins were applied in following order: at first, gender and age of the supplement users were determined from the original dataset; then, the Centrum product which corresponds to particular gender and age group was applied. In addition, all herbal supplements that did not contain and/or were not provided with documented information on the content of at least one of examined nutrients (vitamins A, C, D and calcium) were removed as well as other reported medicines that are not related to dietary supplements. Therefore, the results of this study may slightly underestimate nutrient intakes and overstate the prevalence of nutrient inadequacies in the BC and MA First Nations populations. Similar assumptions about nutrient composition of unknown supplements were made in the previous studies conducted in the US and Canada. Similarly, Blitz et al (2005) developed the Supplement Default Codes to match reported supplements with insufficient detail using the Hawaii-Los Angeles Multiethnic Cohort (MEC) Study data (106).

Some other limitations of the study should also be considered. First, all estimates of dietary intake assume that reported nutrient intake from food sources on 24h recalls are unbiased and that self-reported dietary supplement intake reflects true long-term supplement intake. Another important limitation is that estimates of nutrients from dietary supplements depend largely on label declaration, rather analytical values. Recent analytical data on dietary supplements suggest that actual levels exceed the labeled values for many vitamins and minerals (81,102). For calcium, the average deviation from the label was about 14% (103). In addition to that, calcium is often included in several dietary supplements as a non-medical ingredient, which also leads to underestimation of calcium intake. Finally, the prevalence of nutrient inadequacy was based on dietary and supplements intake data alone, and did not investigate clinical measures of deficiency. Thus, all these limitations should be taken into consideration when interpreting the results.

6.4. Conclusion.

This is the first study that estimates total nutrient intake including food intake and supplement use in First Nations population living on reserves in Canada. The study shows that diet alone fails to provide Canadian Aboriginal populations with adequate intake of nutrients of concern. The majority of BC and MA First Nations adults even after factoring in dietary supplement use had vitamins A, D and calcium intakes below the recommended levels. Thus, these nutrients are of greater concern in both provinces. The use of dietary supplements did not significantly contribute to total intakes of selected nutrients except vitamin C in some age groups. Vitamin and mineral supplements have a potential to improve the micronutrient intake of people with a nutrient-poor diet; however, those at risk for nutrient inadequacy may be less likely to take supplements or the supplement daily intakes may be insufficient. Given the substantial prevalence of low nutrient intakes among most age/sex groups for selected nutrients observed in the present study, the potential contribution of supplements should be further investigated. Furthermore, the results of this study highlight the need of nutritional programs directed toward the improvement of nutritional quality and food security as well as consumption of traditional nutrient dense food in First Nations living on reserve.

References

1. World Health Organization (2003) Diet, nutrition and the prevention of chronic diseases. WHO technical report series 916. (Accessed September, 2012) Retrieved from: http://whqlibdoc.who.int/trs/who_trs_916.pdf

2. Kuhnlein, H.V. Receveur, O., Egeland, G.M. (2004) Arctic Indigenous peoples experience the nutrition transition with changing dietary patterns and obesity. *J. Nutr*. 124: 1447:1453

3. Kuhnlein, H.V., Receveur, O. (1996) Dietary change and traditional food systems of indigenous people. *Annu Rev. Nuw* 16:41742

4. Kuhnlein, H.V., Receveur, O. (2007) Local cultural animal food contributes high levels of nutrients for Arctic Canadian Indigenous adults and children *J. Nutr*. 137: 1110–1114

5. Garriguet, D. (2008) Obesity and the eating habits of the Aboriginal population. Statistics Canada, Catalogue 82-003; *Health Reports*, Vol. 19, No. 1

6. Lawn, J. and Harvey, D. (2004) Nutrition and food security in Fort Severn, Ontario baseline survey for the food mail pilot project. Catalogue No. R2-350/2004E

7. Schaefer, S.E., Erber, E., Trzaskos,J.P., Roache,C., Sharma, S. (2011) Sources of food affect dietary adequacy of Inuit women of childbearing age in Arctic Canada. *J Health Popul Nutr.:*Volume 29 | Number 5

8. Hayek, J.E. et al (2010) Vitamin D status of Inuit preschoolers reflects season and vitamin D Intake. *J. Nutr*. 140: 1839–1845

9. Nakano, T. (2005) Dietary nutrients and anthropometry of Dene/Métis and Yukon children. *Int J Circumpolar Health*; 64(2):147-156

10. Findlay, L.C. and Janz, T.A. (2012) The health of Inuit children under age 6 in Canada. *Int J Circumpolar Health*, 71

11. Findlay, L.C. and Janz, T.A. (2012) Health of First Nations children living off reserve and Métis children younger than age 6. *Health Reports*, Vol. 23, no. 1 Statistics Canada, Catalogue no. 82-003-XPE

12. Committee for healthy ageing bulletin. Calcium supplementation for older people. *NZ nutrition foundation*; No 15, August 2013. (Accessed September, 2013). Retrieved from: www.nutritionfoundation.org.nz/about-nznf/NZNF-Committee-for-Healthy-Ageing

13. Moyer, V.A. (2013) Vitamin D and calcium supplementation to prevent fractures in adults: U.S. preventive services task force recommendation statement. *Ann Intern Med.*; 158:691-696.

14. Craig, W.J. (2010) Nutrition concerns and health effects of vegetarian diets. *Nutr Clin Pract*. Dec;25 (6):613-20

15. Dawson-Hughes, B., Dallal, G.E., Krall, E.A., Sadowski, L., Sahyoun, N., and Tannenbaum, S. (1990) A controlled trial of the effect of calcium supplementation on bone density in postmenopausal women. *N Engl J Med*; 323:878-883

16. Murphy, S.P., White, K.K., Park, S.Y., and Sharma S. (2007) Multivitamin-multimineral supplements' effect on total nutrient intake. *Am J Clin Nutr* 85(suppl):280S– 4S

17. Bailey, R.L., Fulgoni III, V.L., Keast, D.R., and Dwyer, J.T. (2011) Dietary supplement use is associated with higher intakes of minerals from food sources *Am J Clin Nutr* 94:1376–81

18. Garriguet, D. (2010) The effect of supplement use on vitamin C intake. *Health Rep*. 21(1):57-62

19. Anderson, L.N., Cotterchio, M., Boucher, B.A., Knight, J.A., Block, T. (2010) Vitamin D intake from food and supplements among Ontario women based on the US block

food frequency questionnaire with and without modification for Canadian food values. *Can J Public Health*. 101(4):318-21

20. Vatanparast, H., Adolphe, J.L., and Whiting, S.J. (2010) Socio-economic status and vitamin/mineral supplement use in Canada. *Health Reports*. Vol. 21, no. 4

21. Shakur, Y.A., Garriguet, D., Corey, P., O'Connor, D.L. (2010) Folic acid fortification above mandated levels results in a low prevalence of folate inadequacy among Canadians. *Am J Clin Nutr*. 92(4):818-25

22. Health Canada. Baseline Natural health Products Survey Among Consumers, 2005. (Accessed September, 2012). Retrieved from: http://www.hc-sc.gc.ca/dhp-mps/altformats/hpfbdgpsa/pdf/pubs/engconssurvey-eng.pdf

23. Vatanparast, H., Dolega-Cieszkowski, J.H., Whiting, S.J. (2009) Many adult Canadians are not meeting current calcium recommendations from food and supplement intake. *Appl. Physiol. Nutr. Metab.* 34: 191–196

24. Guo, X., Willows, N., Kuhle, S., Jhangri, G., Veugelers, P.J. (2009) Use of vitamin and mineral supplements among Canadian adults. *Can J Public Health*. 100(5):357-60

25 Troppmann, L., Gray-Donald, K., Johns, T. (2002) Supplement use: is there any nutritional benefits? *J Am Diet Assoc*. 102:818-825

26. Chan, L., Receveur, O., Sharp, D., Batal, M., Garcia, D. First Nations Food, Nutrition and Environment Study (FNFNES). (Accessed May, 2012). Retrieved from: http://www.fnfnes.ca/

27. Chan, L., Receveur, O., Sharp, D., Swartz, H., Ing, A., Tikhonov, C. First Nations Food, Nutrition and Environment Study (FNFNES): Results from British Colombia (2008-2009). Prince George: University of Northern British Colombia, 2011. Print. (Accessed May, 2012) Retrieved from: http://www.fnfnes.ca/

28. Chan, L., Receveur, O., Sharp, D., Swartz, H., Ing, A., Fediuk, K., Black, A., Tikhonov, C. First Nations Food, Nutrition and Environment Study (FNFNES): Results from

Manitoba (2010). Prince George: University of Northern British Colombia, 2012. Print. (Accessed May, 2012). Retrieved from: http://www.fnfnes.ca/

29. Radimer, K., Bindewald, B., Hughes, J., Ervin, B., Swanson, C., and Picciano, M.F. (2004) Dietary supplement use by US adults: data from the National Health and Nutrition Examination Survey, 1999–2000. *Am J Epidemiol;* Vol. 160 (4): 339–349

30. Briefel, R.R., Johnson, C.L. (2004) Secular trends in dietary intake in the United States. *Annu Rev Nutr.*24:401–431

31. Rock, C.L. (2007) Multivitamin-multimineral supplements: who uses them? *Am J Clin Nutr.;* 85(suppl):277S–9S

32. Bailey, R.L., Gahche, J.J., Lentino, C.V., Dwyer, J.T., Engel, J.S., Thomas, P.R., Betz, J.M., Sempos, C.T., and Picciano, M.F. (2011) Dietary supplement use in the United States, 2003–2006. *J Nutr.* 141: 261–266

33. Gahche, J., Bailey, R., Burt, V., Hughes, J., Yetley, E., Dwyer, J., Picciano, M.F., McDowell, M., and Sempos, C. (2011) Dietary supplement use among U.S. adults has increased since NHANES III (1988–1994). *NCHS Data Brief*. No. 61

34. Ervin, R.B., Wright, J.D., Kennedy-Stephenson, J. (1999) Use of dietary supplements in the United States, 1988–94. *Vital Health Stat 11*. (244):i-iii, 1-14

35. Balluz, L.S., Kieszak, S.M., Philen, R.M., Mulinare, J. (2000) Vitamin and mineral supplement use in the United States: results from the Third National Health and Nutrition Examination Survey. *Arch Fam Med*. 9 (3): 258-262

36. Industry overview. *NBJ*. Vol IV no 6:1–5. 1999

37. NBJ's Supplement Business Report. (2011 September 1), Penton Media Inc, *NBJ*

38. Rea, P. (2012) Strategic information for the nutrition industry. U.S. Market overview. *NBJ;* 17: 5-6

39. Block, G., Cox, C., Madans, J., Schrelber, J.B., Licitra, L., and Melia, N. (1988) Vitamin supplement use, by demographic characteristics. *Am J Epidemiol*. Vol. 127, No 2: 297-309

40. Koplan, J.P., Annest, J.L., Layde, P.M., and Rubin, J.L. (1986) Nutrient intake and supplementation in the United States (NHANES II). *Am J Public Health*. 76 (3): 287-289

41. Ervin, R.B., Wright, J.D., Reed-Gillette, D. (2004) Prevalence of leading types of dietary supplements used in the Third National Health and Nutrition Examination Survey, 1988-94. *Adv Data*. (349): 1-7

42. Subar, A.F., Block, G. (1990) Use of vitamin and mineral supplements: demographics and amounts of nutrients consumed. The 1987 Health Interview Survey. *Am J Epidemiol*. 132(6): 1091-101

43. Slesinski, M.J., Subar, A.F., Kahle, L.L. (1995) Trends in use of vitamin and mineral supplements in the United States: the 1987 and 1992 National Health Interview Surveys. *J Am Diet Assoc.* 95: 921–923

44. Stewart, M.L., McDonald, J.T., Levy, A.S., Schucker, R.E., Henderson, D.P. (1985) Vitamin/mineral supplement use: a telephone survey of adults in the United States. *J Am Diet Assoc.* 85(12):1585-90

45. Moss, A.J., Levy, A.S., Kim, I. and Park, Y.K. (1989) Use of vitamin and mineral supplements in the United States: Current users, types of products, and nutrients. *Vital Health Stat 11.* (174): 1-20

46. Bender, M.M., Levy, A.S., Schucker, R.E., Yetley, E.A. (1992) Trends in prevalence and magnitude of vitamin and mineral supplement usage and correlation with health status. *J Am Diet Assoc*. 92(9):1096-101

47. Millen, A.E., Dodd, K.W., Subar,A.F. (2004) Use of vitamin, mineral, nonvitamin, and nonmineral supplements in the United States: The 1987, 1992, and 2000 National Health Interview Survey results. *J Am Diet Assoc;* 104: 942-950

48. Radimer, K.L. (2003) National nutrition data: contributions and challenges to monitoring dietary supplement use in women. *The journal of nutrition*. 133: 2003S–2007S

49. Stang, J., Story, M.T., Harnack, L., Neumark-Sztainer, D. (2000) Relationships between vitamin and mineral supplement use, dietary intake, and dietary adequacy among adolescents. *J Am Diet Assoc*. 100: 905-910

50. Looker, A.C., Sempos, C.T., Johnson, C.L., Yetley, E.A. (1987) Comparison of dietary intakes and iron status of vitamin-mineral supplement users and nonusers, aged 1-19 years. *Am J Clin Nutr*; 46: 665-672

51. Dickinson, V.A., Block, G., Russek-Cohen, E. (1994) Supplement use, other dietary and demographic variables, and serum vitamin C in NHANES II. *J Am Coll Nutr*. 13(1): 22-32

52. Dwyer, J.T., Garcea, A.O., Evans, M., Li, D., Lytle, L., Hoelscher, D., Nicklas, T.A., Zive, M. (2001) Do adolescent vitamin-mineral supplement users have better nutrient intakes than nonusers? Observations from the CATCH tracking study. *J Am Diet Assoc*. 101(11):1340-6

53. Kaufman, D.W., Kelly, J.P., Rosenberg, L., Anderson, T.E., Mitchell, A.A. (2002) Recent patterns of medication use in the ambulatory adult population of the United States: the Slone survey. *JAMA*. 287(3):337-44

54. Picciano, M.F., Dwyer, J.T., Radimer, K.L., Wilson, D.H., Fisher, K.D., Thomas, P.R., Yetley, E.A., Moshfegh, A.J., Levy, P.S., Nielsen, S.J., Marriott, B.M. (2007) Dietary supplement use among infants, children, and adolescents in the United States, 1999-2002. *Arch Pediatr Adolesc Med*. 161(10):978-85

55. Shaikh U, Byrd RS, Auinger P. (2009) Vitamin and mineral supplement use by children and adolescents in the 1999-2004 National Health and Nutrition Examination Survey: relationship with nutrition, food security, physical activity, and health care access. *Arch Pediatr Adolesc Med*. 163(2):150-7

56. Bailey, R.L., Dodd, K.W., Gahche, J.J., Dwyer, J.T., McDowell, M.A., Yetley, E.A., Sempos, C.A., Burt, V.L., Radimer, K.L., Picciano, M.F. (2010) Total folate and folic acid intake from foods and dietary supplements in the United States: 2003-2006. *Am J Clin Nutr*. 91(1):231-7

57. Bailey, R.L., McDowell, M.A., Dodd, K.W., Gahche, J.J., Dwyer, J.T., Picciano, M.F. (2010) Total folate and folic acid intakes from foods and dietary supplements of US children aged 1-13 y. *Am J Clin Nutr*. 92(2):353-8

58. Bailey, R.L., Dodd, K.W., Goldman, J.A., Gahche, J.J., Dwyer, J.T., Moshfegh, A.J., Sempos, C.T., and Picciano M.F. (2010) Estimation of total usual calcium and vitamin D intakes in the United States. *J Nutr.*. 140 (4): 817-822

59. Kennedy, E.T., Luo, H., Houser, R.F. (2013) Dietary supplement use pattern of U.S. adult population in the 2007-2008 National Health and Nutrition Examination Survey (NHANES). *Ecol Food Nutr*. 2013 Jan;52(1):76-84

60. Gardner, J.D., and Suitor, S.W. (1990) Supplement use among a culturally diverse group of low-income pregnant women. *J Am Diet Assoc.* 90(2):268-71

61. Cogswell, M.E., Kettel-Khan, L., Ramakrishnan, U. (2003) Iron supplement use among women in the United States: science, policy and practice. *J Nutr.* 133(6):1974S-1977S

62. Picciano, M.F., and K McGuire, M.K. (2009) Use of dietary supplements by pregnant and lactating women in North America. . *Am J Clin Nutr* 89(suppl):663S–7S

63. Branum AM, Bailey R, Singer BJ (2013) Dietary supplement use and folate status during.pregnancy in the United States. *J Nutr.* Apr;143(4):486-92

64. Troppmann, L., Johns, T., Gray-Donald, K. (2002) Natural health product use in Canada. *Can J Public Health*. 93(6):426-30

65. Barr,S.I. (2004) British Columbia Nutrition Survey: report on supplements. B.C. Ministry of Health Services. (Accessed June, 2012). Retrieved from: http://www.health.gov.bc.ca/library/publications/year/2004/bcnutritionsurvey/nutrition_supp.pdf

66. Robson, P.J., Siou, G.L., Ullman, R., Bryant, H.E. (2008) Sociodemographic, health and lifestyle characteristics reported by discrete groups of adult dietary supplement users in Alberta, Canada: findings from The Tomorrow Project. *Public Health Nutr*. 11(12):1238-47

67. Poliquin, S., Joseph, L., Gray-Donald, K. (2009) Calcium and vitamin D intakes in an adult Canadian population. *Can J Diet Pract Res*: 70 (1): 21-27

68 Gray-Donald, K., Jacobs-Starkey, L., Johnson-Down, L. (2000) Food habits of Canadians: reduction in fat intake over a generation. *Can J Public Health* ;91:381-85

69. Health Canada. 2006. Canadian Community Health Survey, Cycle 2.2, Nutrition (2004). A guide to accessing and interpreting the data. Cat. No. H164-20/2006E-PDF. (Accessed June, 2012). Retrieved from: http://www.hc-sc.gc.ca/fn-an/surveill/nutrition/commun/cchs_guide_escc_e.html

70. USDA Agricultural Research Service. USDA Automated Multiple-Pass Method; 2002 August 13, 2009 [cited 2009 Nov 20]. (Accessed October, 2012). Retrieved from: http://www.ars.usda.gov/Services/docs.htm?docid=7710

71. Moshfegh, A.J., Rhodes, D.G., Baer, D.J., Murayi, T., Clemens, J.C., Rumpler, W.V., Paul, D.R., Sebastian, R.S., Kuczynski, K.J., Ingwersen, L.A., Staples, R.C., Cleveland, L.E. (2008). The US Department of Agriculture Automated Multiple-Pass Method reduces bias in the collection of energy intakes. *Am J Clin Nutr.* 88:324 –32

72. Dolega-Cieszkowski, J.H., Bobyn J.P., Whiting, S.J. (2006) Dietary intakes of Canadians in the 1990s using population-weighted data derived from the provincial nutrition surveys. *Appl. Physiol. Nutr. Metab.* 31: 753-758

73. Shakur, Y.A., Tarasuk, V., Corey, P., and O'Connor, D.L. (2012) A Comparison of micronutrient inadequacy and risk of high micronutrient intakes among vitamin and mineral supplement users and nonusers in Canada *J. Nutr*. 142: 534–540

74. Blanchet, C., Plante, C., Rochette, L. (2009) La consommation alimentaire et les apports nutritionnels des adultes québécois. Institut national de sante publique du Québec

75. Colapinto, C.K., O'Connor, D.L., Dubois, L., Tremblay, M.S. (2012) Folic acid supplement use is the most significant predictor of folate concentrations in Canadian women of childbearing age. *Appl. Physiol. Nutr. Metab*. 37: 284–292

76. Whiting, S.J., Langlois, K.A., Vatanparast, H., Greene-Finestone, L.S. (2011) The vitamin D status of Canadians relative to the 2011 Dietary Reference Intakes: an examination in children and adults with and without supplement use. *Am J Clin Nutr* 94:128–35

77. Carriquiry, A.L. (2003) Estimation of usual intake distributions of nutrients and foods. *J. Nutr*. 133: 601S–608S

78. Nusser, S.M., Carriquiry, A.L., Dodd, K.W., Fuller, W.A. (1996) A semiparametric transformation approach to estimating usual daily intake distributions. *J Am Stat Assoc*. 91 (436): 1440-1449

79. Toozem J.A., Midthune, D., Dodd, K.W., Freedman, L.S., Krebs-Smith, S.M., Subar, A.F., Guenther, P.M., Carroll, R.J., Kipnis, V. (2006) A new statistical method for estimating the usual intake of episodically consumed foods with application to their distribution. *J Am Diet Assoc*. 106(10):1575-87

79a. Subar, A.F. et al (2006) The food propensity questionnaire: concept, development, and validation for use as a covariate in a model to estimate usual food intake. *J Am Diet Assoc.* 106:1556-1563

80. Dodd, K.W., Guenther, P.M., Freedman, L.S., Subar, A.F., Kipnis, V., Midthune, D., Tooze, J.A., Krebs-Smith, S.M. (2006) Statistical methods for estimating usual intake of nutrients and foods: a review of the theory. *J Am Diet Assoc*. 106(10):1640-50

81. Dwyer, J.T., Holden, J., Andrews, K., Roseland, J., Zhao, C., Schweitzer, A., Perry, C.R., Harnly, J., Wolf, W.R., Picciano, M.F., Fisher, K.D., Saldanha, L.G., Yetley, E.A., Betz, J.M., Coates, P.M., Milner, J.A., Whitted, J., Burt, V., Radimer, K., Wilger, J., Sharpless, K.E., Hardy, C.J. (2007) Measuring vitamins and minerals in dietary supplements for nutrition studies in the USA. *Anal Bioanal Chem*. 389(1):37-46

82. Garriguet, D. (2010) Combining nutrient intake from food/beverages and vitamin/mineral supplements. *Health Reports*. Vol. 21, no. 4

83. Bailey, R.L., Fulgoni, V.L. 3rd, Keast, D.R., Dwyer, J.T. (2012) Examination of vitamin intakes among US adults by dietary supplement use. *J Acad Nutr Diet*. 112(5):657-663

84. Bailey, R.L., Fulgoni, V.L. 3rd, Keast, D.R., Lentino, C.V., Dwyer, J.T. (2012) Do dietary supplements improve micronutrient sufficiency in children and adolescents? *J Pediatr*.; 161(5):837-42

85. National Cancer Institute. Usual dietary intakes: the NCI method. 2009. (accessed August, 2012). Retrieved from: http://riskfactor.cancer.gov/diet/usualintakes/method.html

86. Foote, J.A., Murphy, S.P., Wilkens, L.R., Hankin, J.H., Henderson, B.E., and Kolonel, L.N. (2003) Factors associated with dietary supplement use among healthy adults of five ethnicities. The Multiethnic Cohort Study. *Am J Epidemiol*. 157(10): 888–897

87. Sebastian, R.S., Cleveland, L.E., Goldman, J.D., Moshfegh, A.J. (2007) Older adults who use vitamin/mineral supplements differ from nonusers in nutrient intake adequacy and dietary attitudes. *J Am Diet Assoc*. 107(8):1322-32

88. Timbo, B.B., Ross, M.P., McCarthy, P.V., Lin, C.T. (2006) Dietary supplements in a national survey: Prevalence of use and reports of adverse events. *J Am Diet Assoc*. 106(12):1966- 74

89. Aboriginal peoples in Canada in 2006: Inuit, Métis and First Nations, 2006 Census.(2008) Census year 2006. *Statistics Canada*. 97-558

90. Gray, J. (2012) The First Nations Information Governance Centre, First Nations Regional Health Survey (RHS) *Phase 2 (2008/10) National Report on Adults, Youth and Children Living in First Nations Communities*. Ottawa

91. A Statistical Profile on the Health of First Nations in Canada: Self-rated Health and Selected Conditions, 2002 to 2005. (Accessed August, 2012). Retrieved from: http://www.hc-sc.gc.ca/fniah-spnia/pubs/aborig-autoch/index-eng.php

92. The health status of Canada's First Nations, Métis and Inuit people. A background paper to accompany Health Care Renewal in Canada: Accelerating Change (January 2005) Health Council of Canada. (Accessed September, 2012). Retrieved from: www.healthcouncilcanada.ca

93. Garner, R., (2010) The Health of First Nations living off-reserve, Inuit, and Métis adults in Canada: The Impact of socio-economic status on inequalities in health. Statistics Canada; Catalogue no. 82-622-X — No. 004

94. Johnson-Down, L. and Egeland, G.M. (2010) Adequate nutrient intakes are associated with traditional food consumption in Nunavut Inuit Children Aged 3–5 Years. *J. Nutr*. doi: 10.3945/jn.109.117887

95. Sheehy, T. et al (2013) Eating habits of a population undergoing a rapid dietary transition: portion sizes of traditional and non-traditional foods and beverages

consumed by Inuit adults in Nunavut, Canada. *J Nutr*, 12:70. (Accessed September, 2013) Retrieved from: http://www.nutritionj.com/content/12/1/70

96. Receveur, O., Boulay, M., and Kuhnlein, H.V. (1997) Decreasing traditional food use affects diet quality for adult Dene/Métis in 16 communities of the Canadian Northwest Territories. *J. Nutr*. 127: 2179–2186

97. Sharma, S., Cao,X., Roache,C., Buchan,A., Gittelsoh,J. (2010) Assessing dietary intake in a population undergoing a rapid transition in diet and lifestyle: the Arctic Inuit in Nunavut, Canada. *Br J Nutr.* 103, 749–759

98. Aboriginal Children's Survey, 2006: Family, Community and Child Care. Statistics Canada. Social and Aboriginal Statistics Division. Catalogue no. 89-634-X,

99. Kozicky, S.K., Mathe,N., Butler,J.L., Sharma,S. (2012) Assessment of supplement use (including vitamin D) in Inuvialuit adults in the Northwest Territories, Canada. *J Hum Nutr Diet*. 26, 169–174

100. Health Canada. *Drug Product Database.* (Accessed December, 2012). Retrieved from: http://www.hc-sc.gc.ca/dhp-mps/prodpharma/databasdon/index- eng.php

101. Statistics Canada. (2007) Canadian Community Health Survey (CCHS) Cycle 2.2 Nutrition, Software for intake Distribution Estimation (SIDE) Documentation

102. Roseland, J.M., Holden, J.M., Andrews, K.W., et al (2008). Dietary supplement ingredient database (DSID): preliminary USDA studies on the composition of adult multivitamin/mineral supplements. *J Food Compost Anal.* 21:S69–77

103. U.S. Department of Agriculture. USDA Dietary Supplement Ingredient Database. (Accessed September, 2012). Retrieved from: http://dietarysupplementdatabase.usda.nih.gov/dsid_database/researh_summary.pdf

104. Zondervan, K.T., Ocke, M.C., Smit, H.A., Seidell, J.C. (1996) Do dietary and supplementary intakes of antioxidants differ with smoking status? *Int. J. Epidemiol.* Vol. 25, No. 1

105. Schleicher, R.L., Carroll, M.D., Ford, E.S. and Lacher, D.A. (2009) Serum vitamin C and the prevalence of vitamin C deficiency in the United States: 2003–2004 National Health and Nutrition Examination Survey (NHANES). *Am J Clin Nutr*; 90:1252–63

106. Blitz, C.L., Murphy, S.P., Foote, J.A., Kolonel, L.N. (2006) Creating default codes and assigning nutrient values for non-specific dietary supplements. *J. Food Comp. Anal*; 19; 5: 453–460

Appendix I

New BC and MA datasets

The names of some dietary supplements provided with DINs did not correspond to the real supplements' names found in Licensed Natural Health Products Database. In order to match these supplements correctly, new datasets were created where all mistaken names of supplements were changed to those having the same DINs. All changes in the new datasets are presented in bold and summarized below:

British Columbia

Supplements "Calcium", "Calcium 500mg", "Rexall Calcium (500mg)", and "calcium carbonate" with DIN 730599 contain calcium and vitamin D, and thus, their names were changed to "Calcium & Vitamin D" in a new dataset.

Supplement "calcium" with DIN 2248374 was renamed "Calcium 500 Mg With Vitamin D".

Supplement "calcium" with DIN 80000280 contains not only calcium, but also vitamin D. Thus, it was renamed "calcium with vitamin D".

Supplements "vitamin C" and "vitamin D" with DIN 682039 both correspond to "calcium carbonate" with the same DIN. Thus, they are renamed "Calcium 500 mg".

Supplements "calcium" and "calciummagnesium" with the same DIN as "calcium magnesium vitamin D", i.e. 2040905 were renamed "Calcium Magnesium With Vitamin D".

A supplement "calcium" with DIN 2040875 corresponds to "calcium magnesium" of Jamieson Laboratories Ltd. with the same DIN and thus, was renamed "calcium magnesium".

Manitoba

A supplement "calcium" with DIN 730599 was renamed "Calcium carbonate/Vit D3" which the same DNI number.

A supplement "calcium magnesium" with DNI: 2040905 corresponds to "calcium with magnesium and vit D" by DIN and was renamed accordingly

NEW BC Dataset

NOID	Supplement1	DIN1	Supplement2	DIN2	Supplement3	DIN3	Supplement4	DIN4
21001	jamieson adult multi	2247613	Jaemisonstressease	2174383				
21002	rolaids		udos oil		oregano oil			
21003	equate cod liver oil	352993	NF learning factors	2246809	jamieson vitamin B6	122645		
21004	iron	623520						
21007	iron	545031	folic acid	426849				
21009	quest total once a d							
21010	multivitamins							
21011	**Calcium & Vitamin D**	**730599**	vitamin D	2240858				
21013	life flax seed oil	80000580	life ester-c 500	2245695				
21014	BwithC complex							
21038	multivitamin							
21053	equatevitaminc	2243893						
22015	Gdnoflifeprimaldefen							
22019	Udo's Choice Oil		Natural Factors Men's +50		Natural Balance Chol-Less		Natural Factor whey factors	
22020	Centrum							
22026	vitamin B-50							
22028	calcium magnesium`							
22039	NF hipotency b	624969	NF vitamin D	780413	NF vitamin A	619086	vitamin B1	494987
22044	oneadayvitamins							
22048	fibre pill							
31009	centrumoneadaymultivit							
31023	jamieson calcium magnesium 333mg/167mg							
31030	**Calcium 500 Mg With Vitamin D**	**2248374**	glucosamine sulfate	80000026	chromium GTF	2050	ultra fibre	
31031	vitamin e 400gm		vitamind 400gm					
31040	bcomplexjamieson		fish oil, life brand		L-carnitine jamieson		flax seed oil	8000193
31043	vitamin A and D	25743	lutein , natural factors					
31055	iron 300 mg		vitamin D					
31085	jamieson vitam3		jamieson vitc					
32005	centrun select	2246346						

32010	super vitamin for men jamieson		vitamin D	2242175	**Calcium Magnesium With Vitamin D**	**2040905**		
32013	ferrous gluconate	545031						
32029	calcium vitd							
32046	centrum	84668	calcium	2248374				
32051	jamieson 50+vitamin	49360107						
41010	MV for women		calcium managmate					
41019	vitamin C							
41035	herbal liquid							
41080	blueberry vitamin							
51013	prenatal-WN Pharma	2244574						
51019	vitamin C 1000mg	401846						
51022	women's formula							
51025	prenatal supplement	2244574						
51026	one a day for women							
51030	multivitamin							
51034	calcium/vit D 500mg	2237351						
51038	calcium magnesium	2244862						
51041	Mega Vim	49220047	Inno-cal-magnesium	10817011				
51042	Ca+ Carbonate 500mg		vitamin D 1000IU	323179				
51048	stress ease B vitmai	2174383	Garlic Life Brand		one a day for women- Jamieson			
51051	multivitamin							
51052	Jamieson w-3 complet	76						
51055	One a day (multivit)	2248293						
51064	children MV		graphite LM					
51068	salmon oil							
51070	centrum select 50		calcium w/ vit D					
51071	life vitamin	2244863						
51075	vitamin B							
51077	One a day MV							
51078	prenatal vitamin							
51081	calcium & magnesium							

51089	prenatal vitamin	2244574						
51091	ground ginger		flaxseed		ground garlic			
51096	mega vim jamieson		proaxtina	22040908				
51100	vita-vim jamieson	1331375	euro-cal 500mg	2237351				
52044	multivitmain	2244864						
52062	vitamin B	2245047						
52097	zinc 50mg	505463						
61003	calcium							
61008	vitamin D 2000 IU		zinc					
61016	centrum 1 /day for women							
61018	multivitamin	2241008						
61022	vitamin B6, B12							
61031	vitamin C							
61034	vitalax		black coho					
61035	calcium	2240973	centrum setec over 50	2246440				
61037	dailyvitaminsforwomen	2242935	vitamincchewable					
61066	prenatal vitamin	2244574						
61079	cod liver oil	8000996	oneadayover50		vitaminc	1994336	calciummagnesium	2040905
61082	vitaminc	1994336	dailyone(women)life		**calcium magnesium**	**2040875**	col liver oil	305146
61105	prenatal	2244574						
61106	calciummagnesium	2241554						
61111	iron infusion hospital		iron supplement					
62017	cod liver oil		multivitamins					
62104	multivitamins		halibut liver oil					
71001	Intramax							
71020	One a day- women		Vitamin E					
71031	One a day- women's							
71033	Daily One- women							
71039	calcium/vit D 500mg							
71045	Once a day-women							
71050	centrum materna							

71057	New Chapter-Only One							
71059	Vitamost- Ultragest		betacol		New Chapter- Only One			
72005	Intramax		all in one- dietary supplement					
72043	ginseng tablets							
72044	Multivitamin							
72047	multiplus multivit							
81035	herbal supplement	2242937						
81036	vitamin b12	335940	iron	2244532	**calcium magnesium**	**2040875**	centrum	2246362
81042	multivitamin	22243926						
81051	calcium	2238525	calcium	2238525	vitamin b12	335940		
81057	prenatal vitamin	2244571						
81063	calcium w/ vit d		calcium w/ vit d					
81065	vitamin b12							
81069	vitamin b12	335940						
81071	Thiamine		Glucosamine					
81082	vitamin b12							
81083	vitamin b12							
81089	arthur chewable multivitamin							
81138	osteo pro care							
82034	vitamin b12	335940						
82043	jamieson multivitamin							
82062	mulitvitamin/mineral							
82086	b vitamins							
82102	vitamin c							
91030	Centrum	2246362						
91032	vitamin D		calcium					
91070	multivitamin	2246346	**Calcium & Vitamin D**	**730599**	glucosamine 500mg	14796		
91072	Centrum	2246792	**Calcium & Vitamin D**	**730599**				
91073	Jamieson vitamins C and D	1319676						
92050	iron pills							
101002	womens multivitamin							

101006	womens multivitamin								
101009	materna	80001842							
101010	womens multivitamin		vitamin E		menosense	80006313			
101012	womens multivitamin		vitamin d		vitamin e				
101023	kirkland calcium plus		kirkland formule (?) forte		goldseal wild salmon oil				
101026	centrum multivitamin								
101038	super lysine w/ vit c & 5 herbs								
101044	womens one a day	2243926							
101047	vitamin c								
101048	prenatal supplement	2244574							
101052	centrum advantage multivitamin								
101062	womens one a day	2243926							
101066	centrum multivitamin								
101067	kaka nutri multi for women								
101071	nordick daily supplement	80005742							
101079	vitamin c								
101086	womens ultra mega 50+	57726	calcium + magnesium						
101087	vitamin c								
101092	vitamin c								
101095	womens one a day								
101101	caltrate with vitamin d	2231948							
101104	iron	582727							
101107	platinum multivitamin activ-x		b100 complex	498815	echinacea high potency	80008222			
101116	apo-ferrous gluconate 300mg								
101120	multivitamin - rexall one a day		vitamin d						
102035	calcium								
102054	centrum multivitamin								
102072	power vitamins for men	2229413							
102082	centrum select 50+	80005153							
102100	vitamin c	2240886							
102105	centrum multivitamin	80005174							

111002	women's one a day	281768						
111012	jamieson for women	1666170	jamieson super calcium	1679434	vitamin C	567089		
111038	multisure	552057	beta carotene	1338397	lecithin	1454509	omega 3	1061805
112013	centrum 40							
112019	multivitamin	510892						
121009	mylan eti cal	2247323	calcium magnesium	1577682				
121010	vitamin c	1994336	echinacea					
121019	prenatal vitamins							
121026	daily one weight sense	2248315						
121030	multivitamin	2243393						
121043	jamieson echinacea							
121050	one a day vitamins		garlic pills		liquid manganese		vitamin and bones calcium	
122003	centrum one a day							
122045	multi vitamin		fish oil					
122047	vitamin d		multivitamin					
131006	women's ultra mega	2227924	vitamin A	297720	FloraSil		vitamin e	814342
131016	jamieson a	297720	caltrate plus	80002972				
131021	vitamin c							
131038	sunkist vitamin c	2238355						
131042	albi natural acai berry		extra energy					
131045	multisure for women							
131046	women one a day advance multivitamin	2243926						
131047	cod liver oil	2245310	vitamin a	297720	vitamin d	80003663		
131057	one a day woman	2243926						
131062	centrum forte complete							
131068	glucosamine sulfate	80000188	senekot	26158				
131071	prenatal vitamins	2244574						
131073	vitamin d	80000436						
131099	chewable vitamin c 500 mg		coenzyme q10					
131101	jamieson vitamin c		sunkist vitamin c	2240886	ginkgo			
131118	B100 complex	498815	neo citran	2217147				

131121	echinacea	551627	mutli vitamin one a day	27168411	vitamin c, bayer, redoxon			
131122	one a day mutlivitamin	27168811						
131125	centrum select 50+	440044						
132002	power vitamins for men	2229413						
132023	zinc	1994018	vitamin c		omega 3,6,9	80000884	calcium magnesium	2048965
132040	c and d3	50350128						
132054	essiac							
132075	voltaren sr 100		pariet					
132096	calcium magnesium with zinc							
132098	multivitamin and mineral 50 plus	2248834						
132100	centrum a-z	8000574						
132114	jamieson super vita vim super		jamieson calcium magnesium	2040875	jamieson omega 3 6 9	80000884	jamieson prime c	1994336
141003	prenatal vitamin	2244574						
141004	**calcium with vitamin D**	**80000280**	omega 3-6-9 (Jamison)		calcum magnesium (Jamison)		vitamin D	
141015	vitamin D		Vitamin B complex		multivitamin		salmon oil	
141024	rexall complete multivitamin		Rexall vitamin D (400 IU)	2240858	**Calcium & Vitamin D**	**730599**		
141035	Optimum super multivit		omega 3		vitamin C		Vitamin D	
151017	multivitamin		vitamin d					
151029	calcium magnesium vitamin d	80007103	vitamin d	2248828	centrum select	80005153	vitamin c	305235
151033	vitamin D3	2229879	calcium carbonate	682039				
151035	recovery purica	3303770	pacific seal oil					
151040	pacific balance omega 3							
151044	calcium		vitamin D					
151045	centrum forte	467381						
151054	beta carotene	764949	selenium	554987	calcium magnesium vitamin D	2040905	vitamin E 400 IU	122858
151056	**Calcium 500 Mg**	**682039**	vitamin D	2229879				
151058	**Calcium 500 Mg**	**682039**						
151071	replavite B and C vitamins	2244872						
151077	glucosamine sulfate	80000370	vitamin b6	122645	calcium magnesium	2048965	multivitamin/minerals	2244988
151082	vital greens							
151091	vitamin d	80002452	metamucil tablets	2247034				

151108	vitamin d	2229879	calcium apothecave	682039				
151116	prenatal vitamins	2244574						
151119	centrum select 50+							
152025	vitamin B 50 complex	598577	tab apo calcium	682039				
152026	multivitamin complete adults	2244990						
152039	jamieson glucosamine							
152060	the ultimate one	38218	vitamin d	2248828	natural factors B12	80003759	albi naturals 1112 mg	
152065	vitamin d	2248828						
152067	rolaids							
152107	centurm select a - z							
152114	ultimate one for men	2244977	ginseng					
161039	vitamin B							
161043	jamiesons vitamin e		centrum multivit					
161044	multivit 50+		garlic pills		vitamin D		ginko	
161046	cod liver oil		bazheng san HJ-073	2730073				
161068	flax oil		calcium					
161080	Iron							
161083	digestive enzymes		mona VIF		silver shield	42764		
161091	iron		vitamin c					
161095	jamiesonforwomanvitavim		genuine healthgreens		genuinehealthdailydetox			
161111	rexall calcium and vitamin D							
162056	centrum multi	80005153						
162086	centrum multivitam							
162096	vitamin B Swiss							
162105	centrum multivitamin		ginseng					
162120	rexall multivit	80000996	cod liver oil-jamieson					
171023	vitamin D		nova-calcium					
171032	al multivit		omega 3-6-9		vitamin c		vitamin D and calcium	
171040	vitamin B							
171044	calcium 1000mg		vitamin D 1000mg		wild salmon oil		vitamin B	
171046	vitamin D	1102688	calcium	1102684	echinacea, golden seal	26913311		

171051	multivitamin -post natal		vitamin D					
171057	women's 1 a day							
171058	platinum super easy multiplus		wildsalmonandfishoil		lifetimecalciummagliquid			
171061	calcium magnesium							
171064	centrum multivitamin	84914						
171072	vitamin B		vitamin C		multivitamin		salmon oil	
171074	vitamin D							
171079	vitamin C							
171090	calcium 1000mg		vitamin D		vitamin B12		vitamin B6	
171106	multivitamin							
171108	centrum multivita							
172001	life vitamin E							
172002	spectrum multi-vitamin							
172007	centrum multivitamin							
172011	vitamin B/folic acid							
172076	folic acid (pre-natal)							
172096	calcium		vitamin D					
181001	folic acid							
181004	multivitamin	2244864						
181009	B50 Rises energy							
181010	materna	80001842	**Calcium & Vitamin D**	**730599**				
181020	vitamin d 400 IU	2244759	vitamin C 500mg	36188	vitamin B12	305243		
181022	calcium		vitamin D					
182002	b12	480878						
182012	calicium with vit d							
182013	centrum select 50+	80005153						
182016	B12 50mg	305243	B1 100m	294853				
191001	acti vit beach body		jamieson B100		omega 3	31008		
191012	calcium with vitamin D							
201008	calcium carbonate	682039	vitamin D	2240858				
201015	aloe vera juice							

201019	prenatal	80001945						
201028	materna	2248555	vitamin C	1994336				
201031	vitamin C 500mg	1994336	prenatal vitamin	2248555				
201032	multivitamin		calcium					
201037	echinacea		olive leaf pill		astragialustincture		cranberry pill	
201045	multivitamin		vitamin C		B12			
201048	mineral complex with calcium		multivitamin & mineral					
201064	omega 3-6-9	80000884	materna	80000842				
201065	omega 3	80004542	praire natural CLA force		Niacin		vit C	1994336
201071	calcium with vitamin D							
201086	vitamin C	2240886						
201087	enerex super phytoplankton	11066						
201088	vitamin D							
201093	vit C							
201098	replavite	2244872						
201099	vitamin b12	305243	vitamin d	80000131	vitamin c	266086	calmax original-dietary supplement	
201106	agel packets							
201110	one a day	2243926						
201113	mulberry extract caps							
201116	hylands	2236694	vitality calicum	34026003				
202003	vitavim adult 50+		calcium liquid capsule					
202046	one a day	2244890	magnesium citrate	1900390				
202060	vitamin B6	329185						
202070	berdock seed tinture							
202081	multivitamin							
211015	1 a day vitamin	2248293	vitamin C					
211022	centurey select 50+	8005153	calcium 500 mg	2230240	natural vitamin D	80002240		
211044	Halls Viamin C 60 mg/drop							
211056	Halibut liver oil (vitamin A 5000IU , vit D 400IU	275743	o-calcium plus D Equate brand	730599	cold fx			
211061	women's formula	245222						
211086	one a day womens multi	2243926	sunkist vitamin C 500mg	2239356				

211100	seal oil -omega 3		B-50 complex		vital greens			
211101	calcium citrate with Vitamin D	2240242	sunkist Vitamin C	2238358				
212004	clinical strength		green tea, 1000 mg					
212078	equate vit. C	784591	euate Vit. D	80000131				
221010	calcium magnesium	2040875	omega 3	800025	centrum 50+			
221012	vitamin B12		calcium		vitamin C			
221029	Omega 3 Fish oil		Natural Zinc	901461	Multivitamin 50+	2242939	Vitamin D	2248826
221033	Vita-Vim drink	1331441	Glucosamin Sulphate (Jamieson)					
221048	omega 369	80000884	Centrum Silver with Lutein		calcium magnesium with zinc	2239697	tums extra streng	1967932
221060	calcium 500 mg	2246178	vitamin D 1000IU	299383				
221083	multivitamin		vitamin D		omega 3		garlic	
221088	calcium plus	80008479	garlic pill		vitamin B12	335940		
221092	one a day	2248293						
221116	actonel 35 mg	2246896	vitamin D 1000IU	299383	calcium 500 mg	226178	garlic oil extrct 1500 mg	
221120		335940						
221121	vitamin D	299383	calcium	2246178				
222027	Enviro-D-T-X							
222068	Vitamin E		Calcium	2246178				

NEW MA Dataset

Noid	Supplement1	DIN1	Supplement2	DIN2	Supplement3	DIN3
231004	Centrum Select 50+	47006				
231010	Caltrate calcium tablets					
231025	Calcum Mg	80007103				
231043	calcium 500 mg		Vitamin D3 (Swiss brand)	80009580	Viamin B12 (Jamieson Brand)	335440
231045	Vitamin D 400 IU		Calcium 500 mg			
231047	Calcium					
231052	Vit B12 1000 mcg (Swiss Herbal)	2237736				
231064	Vivitas Woman vitamin	80009662				
231074	Calcium carbonate/Vit D3	730599				
231080	Centrum 50+	80005153				
231106	iron (prescription)					
231119	vitamin D		calcium		potassium	
232007	Vitamin B12	2237736				
232056	Vitamin Mineral Supplement	2236405				
232062	Viamin B Complex		Cod liver oil		metamucil	
241002	Rolaids	2240505				
241004	Vital Greens – noka	30110	Vitamin C - Jamieson, Natural Source	1994336		
241051	Centrum multivitamin	80005174				
241075	ferrous gluconat	2244536	Bayer Women one-a-day	2243926		
251008	**calcium with magnesium and vit D**	**2040905**				
251016	womens multivitamins	81899348				
251056	**Calcium carbonate/Vit D3**	**730599**	resedronate sodium	2246896	ferrous fumarate	1923420
251065	iron palafen	923420				
251089	calcium carbonate	2240240	Vitamin D	2245842		

251102	ferrous sulfate					
251108	Magnesium	925858				
252001	one a day	81899348				
252095	centrum select 50	54801	vital greens naka	50601		
252123	vitamin b12	2237736				
261004	Appo-ferrous sulphate	1912518				
261053	ferrous sulphate	1912518				
261062	Flintstone	20533082				
262036	Centrum					
262037	potassium w iron	176754				
262058	vitamin B12		Vitamin D		calcium	
271005	folic acid	2048841	iron	346918	prenatal vitamin	80005770
271006	vitamin D	80008795				
271007	Materna					
271052	vitamin b12	80006780	omega 3-6-9		calcium and magnesium	340501
271055	prenatal vitamin	2244374				
271059	calcarea carb	8020210	ignatia amara	8020212	columbrina	8020211
271083	womens one a day	2243926				
271085	vitamin d3	323179	calcium	682039		
271086	vitamin c	8000359	vitamin d and calcium	80000436		
271091	apple cider vinegar	447799				
271098	prenatal postpartum with folic acid	2244374				
271106	centrum 50+ multivitamin					
271108	materna prenatal	80001842				
271110	vitamin b12	450642				
271115	ferrous sulfate	346918				
271118	prenatal w folic acid	80005770				

271119	prenatal w folic acid	2244374					
272066	calcium with d3	80000908	multivitamin	81163120			
272100	vitamin b12	335948					
281005	omega 3-6-9	80000884	vitamin e	330191	caltrate	2231948	
281007	vitamin d	330845	calcium	7867200			
281010	ferrous sulfate	346918	materna	80001842			
281014	women's centrum	2243926					
281056	Materna	80001842					
281100	centrum select	2246440					
301015	vitamin D prescription		calcium prescription				
301047	dr. miller's holy tea						
301064	vitamin D	299383					
301087	Benefibre		calcium 500 mg with Vitamin D Webber Naturals				
302020	preferred pharmacy complete multi						
302035	vitamin D Northmart Pharmacy						
302039	unknown prescription						
302040	Multivitamin						
302054	one a day, men						
302058	jamieson wild salmon fish oil complex		jamieson multivitamin				
331002	vitamin c	2240886					
331003	multi-vitamins	2244864					
331005	Multivitamin	2244864	vitamin d	2245842			
331012	calcium soft chews	80012593					
331013	vitamin a	635588	vitamin b12	2023598	vitamin d	2245842	
331016	prenatal vitamin						
331020	Multivitamins						
331032	vitamin c walmart brand						

331057	Calcium	682039	vitamin d	80002452	multivitamin	
331064	Iron	31100				
331070	Multivitamin		caltrate	2231948		
331088	Iron	31100				
331089	vitamin d					
331099	prenatal vitamin		iron			
331100	Mulitivitamin		vitamin d			
332053	Multivitamin	2244864				
332082	Multivitamin	2244864				
332084	Multivitamin	2244864				
332085	calcium with magnesium and vit D					
332110	Multivitamin	2244864				
341002	calcium hydrochloride					
341008	**Calcium carbonate/Vit D3**	**730599**				
341059	ferrous gluconate	545031				

Appendix II

Dietary Supplement Questionnaire

Participant ID: __ __ / __ / __ __ __

SUPPLEMENT FORM

1. Yesterday, did you take any of the following: nutritional supplements, vitamins, minerals, or herbal, botanical or homeopathic preparations? Y/N
2. In the last month, did you take any other nutritional supplements, vitamins, minerals, or herbal, botanical or homeopathic preparations? Y/ N
3. Please tell me the name of all these products with their DIN/NPN (when available) that you took yeaterday or during the last month. (DIN is a Drug Id. # and NPN is a Natural Product Id. #)
4. Yesterday, at what time did you take your supplements and how many pills (tablets, capsules, teaspoons, etc.) were taken at each time?
5. In the last month, how often was each of these supplements taken? (Number of times per day, per week or per month)
6. How many pills (or tablets, capsules, teaspoons, etc.) were usually taken on each occasion?

Supplement name	DIN/NPN	In the past 24 hrs		During the last month			
		At what time	# pills, tabs, caps, tsp..	How often			How much
				day	week	month	# pills, tabs, caps, tsp..