VITAMIN D DEFICIENCY

IN THREE NORTHERN MANITOBA COMMUNITIES

BY

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A Thesis
Submitted to the Faculty of Graduate Studies
in Partial Fulfillment of the Requirements
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ABSTRACT

Background: The remote Aboriginal communities in the Island Lake area of Manitoba have high rates of rickets, unlike other seemingly-similar communities. Two Island Lake communities (Garden Hill and St. Theresa Point) and Norway House, a community without known rickets were chosen for this study. Clinical rickets in children, vitamin D deficiency in pregnant women, and risk factors for vitamin D deficiency and rickets were hypothesized to be greater in the Island Lake area than in Norway House. From a review of the literature from several disciplines, I hypothesized that vitamin D deficiency was prevalent in Norway House, despite the absence of known rickets.

Methods: A historical prospective study of the incidence of clinical rickets in treaty-status Aboriginal children born in 1993 and 1994 (a retrospective chart review of birth cohorts) was conducted. A cross-sectional serum survey was conducted to determine the prevalence of vitamin D deficiency (25-hydroxyvitamin D <35 nmol/L) among pregnant woman. A cross-sectional interview survey was also conducted among these women to investigate the presence, strength, and amenability to change of risk factors for vitamin D deficiency.

Results: The rickets incidence rate was 85/1000 for Garden Hill and 55/1000 for St. Theresa Point, and there were no cases from Norway House. The prevalence of vitamin D deficiency among pregnant women from all three communities was 84.6% (n=115), with 84.4% in Garden Hill (n=32), 91.4% in St. Theresa Point (n=35), and 78.4% (n=37) in Norway House. Significant differences were found between Norway House and Garden Hill in vitamin D status, education, family income source, and several risk factors for vitamin D deficiency and rickets.

Conclusion: The interview data (n=95) provided insight into the possible reasons for vitamin D deficiency and factors to consider for prevention. Multiple logistic regression analyses were not possible due to the homogeneity of results among pregnant women in all three communities. However, finding widespread vitamin D deficiency in Norway House may be important if vitamin D deficiency has a role in common conditions, such as Baby-bottle Tooth Decay, as I hypothesize from a review of the literature from several disciplines.

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1. INTRODUCTION

Since the discovery that vitamin D could be manufactured and added to the human diet via food fortification or vitamin supplements, the problem of vitamin D deficiency has generally been regarded as solved. Public health efforts in Canada led to the vitamin D fortification of fluid milk, mandatory since 1975. In Manitoba, milk has been fortified with vitamin D since 1968 (1). Vitamin D-deficiency rickets has since been virtually eliminated for most Canadians. However, rickets persists for some, especially Aboriginal children and children of recent immigrants of Asian or African origin (2, 3).

For decades, the remote Aboriginal communities in the Island Lake area of Manitoba (see Figure 1) have had many cases of rickets. The reasons for rickets in this area and not in other, seemingly-similar, communities were unknown and public health efforts to eliminate rickets have failed. Two Island Lake communities and one comparison community (without an apparent rickets problem) were chosen for study (see Appendix 1). However, based on an extensive review of the literature from several disciplines, I hypothesized that vitamin D deficiency, although of a lesser extent and magnitude, would be found in the comparison community where little or none was expected before. This study sought to document rickets incidence rates, vitamin D deficiency prevalence rates in pregnancy, and to add to our understanding of the risk factors for deficiency and why one area has a rickets problem while the other does not. This study also sought an understanding of the beliefs and practices that influence the potential for change of risk factors for prevention.

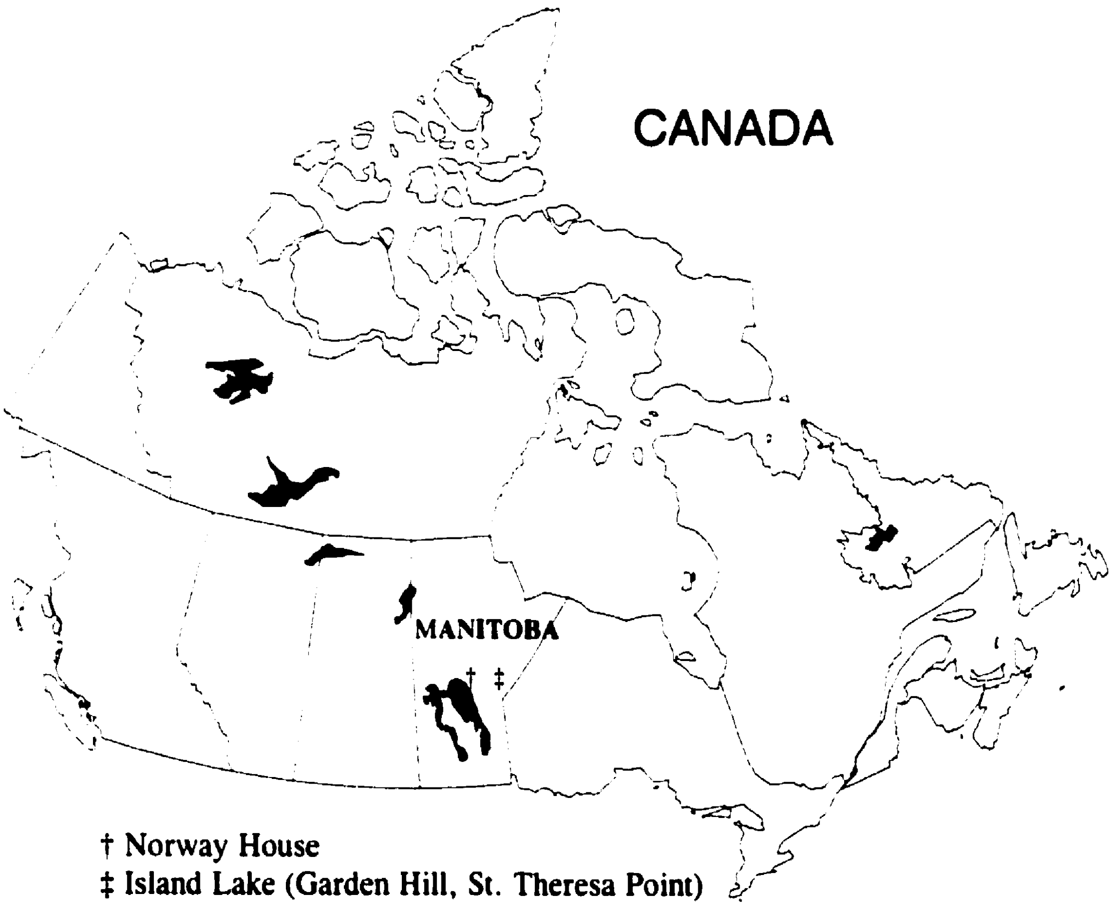

Figure 1: Map of Canada Showing Location of Study Communities in Manitoba

2. LITERATURE REVIEW

2.1 Literature pertaining to rickets

2.1.1 The Role of Vitamin D in Rickets and Osteomalacia:

Vitamin D is required for calcium homeostasis. Insufficient vitamin D causes impaired intestinal calcium and phosphorous absorption. Parathyroid hormone is then released, mobilizing calcium and phosphorous from the bones, potentially weakening them. Bone matrix is produced, but calcification is impaired (4, 5). In infants, epiphyses become enlarged (6). The legs deform from weight bearing or even muscle pull, which can cause bowing of the arms and legs. The skull is also affected (craniotabes, enlarged sutures, flattening, delayed fontanelle closure, and parietal bossing). Kyphosis, scoliosis, and compression of the pelvis are rare but can lead to maternal and infant death in childbirth (6, 7).

Numerous non-skeletal manifestations occur with rickets. Hypocalcemia frequently causes seizures, tetany, laryngospasm, or myocardiopathy. Other clinical signs of rickets are hypotonia, anaemia, hypophosphatemia, and hyperparathyroidism. Rib cage weakness and deformation can cause severe pulmonary impairment, leading to ventilation problems and infection (6). The period of greatest risk for rickets is the first 18 months of life (6, 8), but clinical and radiological signs of rickets occur in individuals with long-standing vitamin D deficiency and vary with age, severity and duration (6). Adolescence is also a period of rapid bone growth that can be associated with rickets and the fatigue and bone pain that accompany rickets (6). After the epiphyses have closed, prolonged vitamin D deficiency leads to osteomalacia, the adult version of rickets. Again, the calcification of the skeleton is impaired, this time during the continual process of remodelling (9). Osteomalacia may be asymptomatic but typically causes muscle and bone pain, weakness, and irregular gait (9, 10).

2.1.2 Vitamin D and the Etiology of Rickets.

Despite the success of oral vitamin D in prevention of rickets, or perhaps because of it, the specific etiology of rickets is unclear (11, 12) and roles for vitamin D beyond calcium homeostasis are still being discovered. Much of what was thought to be understood about vitamin D has recently been found to be either incorrect or only partly correct.

2.1.2.1 Vitamin D is not a vitamin.

Vitamin D is actually a prohormone that is converted in the body to a hormone (13). Vitamin D regulates calcium levels in the blood through its effect on intestinal absorption and skeletal mobilization of calcium.

2.1.2.2 Vitamin D is not commonly found in food (5, 12, 14).

There are very few foods that contain vitamin D, usually in minute quantities. These foods are of animal origin and reflect the sites of synthesis or storage of vitamin D such as organ meats and egg yolk (14, 15). However, vitamin D can be added to foods as a supplement.

2.1.2.3 Humans do not require a daily dose of vitamin D.

The belief that a daily dose was required follows from the mistaken identification of vitamin D as a micronutrient. The role of sunlight in the prevention and treatment of rickets was suspected for more than a century before it was demonstrated almost eighty years ago (15). Stephens and colleagues (16) question the concept of a daily dietary requirement when the amount generated from the sun exceeds the dietary source and can be stored. Vitamin D is generated in skin upon exposure to ultraviolet B solar radiation of the wavelengths 285 to 310 nm. Depending on latitude, these rays are available only seasonally. In Los Angeles (34°N) people can make vitamin D year-round, in Edmonton (52°N), for only 6 months of the year (17). Even casual sun exposure provides sufficient vitamin D. As little as 10 to 15 minutes of sun exposure, two to three times a week, hands, arms and face only is more than adequate for the elderly in Boston (42°N) (15).

2.1.2.4 Pigmentation may not significantly reduce the skin's ability to make vitamin D.

Because rickets is more prevalent among darker-skinned people, it has been proposed that melanin interferes with the body's ability to synthesize vitamin D (18, 19). However, these studies were poorly controlled, and, given that very little ultraviolet light is required, the association of low vitamin D status with skin colour may be a marker for socioeconomic status (20).

2.1.2.5 Breastmilk and sunlight are not the most important sources of vitamin D for infants.

Only small amounts of vitamin D are transferred in breastmilk, even if the mother has high serum levels, and, in Canada, few infants receive much sun exposure. More importantly, babies are born with a store of vitamin D (8, 21-25).

2.1.2.6 Rickets does not necessarily begin as a pediatric disorder.

The adequacy of the vitamin D store of the newborn is dependent on the adequacy of the mother's vitamin D status (21, 23-25). Many preventive efforts are aimed at preventing rickets without addressing the underlying problem of maternal vitamin D deficiency and potentially widespread vitamin D deficiency in the community.

2.1.2.7 Rickets is not always associated with a lack of sunshine.

Although rickets is considered a disease of civilization and poor living conditions that result in a lack of sun exposure (13, 15), the highest rates of rickets are often found in tropical areas with abundant sunshine (5). Because so little ultraviolet light is needed, it seems unlikely that people who are not house- or institution-bound do not get enough, provided the rest of the pieces are in place to ensure a healthy metabolism.

2.1.2.8 Vitamin D might not be the most important factor in rickets etiology (26).

Apparently, vitamin D metabolism is most efficient when 25-hydroxyvitamin D is in short supply (27). Calcium homeostasis is controlled in a feedback loop involving many factors. It has been proposed that calcium may play a more important role than previously thought (12). Low calcium consumption, or low bioavailability, may increase vitamin D needs due to increased metabolic inactivation of vitamin D (6, 12, 28, 29). High fibre and high protein diets have been found to impair calcium absorption. Vitamin D deficiency can lead to hypocalcemia, and excess vitamin D can lead to hypercalcemia. Although serum calcium levels are tightly regulated and are usually maintained within a narrow range of healthy levels, habitual low calcium consumption can cause low 25-hydroxyvitamin D levels (subclinical vitamin D deficiency) (28). Testing the theory that the low calcium/high cereal diet typical of populations susceptible to rickets might affect the efficiency of vitamin D utilization led to the finding that the rate of inactivation of vitamin D in the rat liver is increased with decreasing calcium (28). The effect is mediated by 1,25-dihydroxyvitamin D which is produced in response to secondary hyperparathyroidism (28). This finding was purported to provide a unifying mechanism for the development of vitamin D deficiency in many clinical disorders and increased understanding of the pathogenesis of rickets (28). Calcium deficiency has been found to cause rickets in children with adequate vitamin D intakes (30, 31).

2.2 Literature pertaining to the hypothesis that vitamin D deficiency is common in the comparison community despite the lack of an apparent rickets problem: a role for vitamin D deficiency in Baby-bottle Tooth Decay?

2.2.1 Vitamin D has a biological role beyond whole-body calcium homeostasis (12, 32).

Vitamin D receptors are present in most nucleated cells of the body (32, 33). Their purpose is not understood and this has made some researchers wary of using oral vitamin D, especially in high doses, which allows the levels to become much higher than ever result from the sun alone (12, 34, 35). Hypervitaminosis D never occurs as a result of sun exposure (5), due to the metabolic regulation of vitamin D and the ability to create biologically inert isomers with continued sun exposure (15).

2.2.2 Enamel hypoplasia and caries:

The knowledge of an association between rickets and defective teeth dates from at least 1743 (36). The specific association between rickets and enamel formation, calcium content, delayed shedding of deciduous teeth, delayed eruption of permanent teeth, and irregular and crowded arrangement in the jaws, was studied early this century (37).

More recent studies have also reported enamel hypoplasia associated with tetany in infants (38, 39). In one of these studies, hypocalcemic seizures occurred between the fifth and tenth day of life and the hypocalcemia was corrected within 24 hours of diagnosis. Yet all 12 of these children exhibited enamel hypoplasia, compared to only 3 of 250 children with no history of hypocalcemic tetany (and no records of neonatal serum calcium levels) (38). The second study found that 56% of 112 infants with neonatal tetany later showed severe enamel hypoplasia of the deciduous teeth (39). Unfortunately, that study failed to provide the proportion of children with no history of tetany that had severe enamel defects of this type. Histological exams revealed prolonged disturbance of enamel formation in the 3 months prior to birth. The investigators suggest this was a manifestation of vitamin D deficiency during pregnancy, likely due to secondary hyperparathyroidism. Infants with 'congenital rickets' commonly present with hypocalcemic seizures. Fraser and Nikiforuk proposed hypocalcemia to be the unifying concept behind enamel hypoplasia (40). There is strong evidence that enamel hypoplasia predisposes teeth to caries (40).

The term 'Baby-bottle Tooth Decay' is believed to represent a distinct clinical entity of known etiology. Baby-bottle Tooth Decay is a disease condition in young children believed to be caused by improper feeding practices (41). Rapid and extensive destruction of the deciduous teeth occurs in the order of eruption, with the exception of the mandibular anterior teeth that are almost always spared (42-45). Proximity to saliva glands and the position of the tongue over the lower teeth during nursing is proposed to explain the lack of caries in these teeth (42, 43, 46). The current etiologic hypothesis suggests that Baby-bottle Tooth Decay is completely preventable by changing infant feeding practices, and prevention efforts have focused on education aimed at this type of behaviour change in individuals. Prevention efforts have had little or no success (47), despite evidence that awareness of the problem and the implicated behaviours is high in parents of both affected and unaffected children (48-51).

2.2.2.1 Prevalence of Baby-bottle Tooth Decay:

Baby-bottle Tooth Decay has a very high prevalence in low socioeconomic populations. Reported prevalence rates of Baby-bottle Tooth Decay in North America, Britain and the United States range from 3% to12% (52-56). Although the overall prevalence in North America is expected to be as low as 5%, the rates are much higher in certain subpopulations (Aboriginal, Hispanic, Asian, inner-city), as in developing countries (42). The reported rates in Aboriginal children in North America range from 17% to 100%, and are almost always over 50% (48, 57-62). Prevalence in Inuit children in the Keewatin was over 80% (48) compared to a prevalence of 3.2% in a non-fluoridated Canadian city (52).

2.2.2.2 Current model of causation in tooth decay:

The general model of tooth decay calls for time and three elements: bacteria (as caries is an infectious disease), sugar to feed the bacteria, and a tooth for the bacteria to colonize (42). The presence of a tooth is required because the bacteria implicated in tooth decay cannot colonize the mouth until a non-shedding surface (tooth) is present. With all of these factors, caries occurs. However, not all people with all of these factors get caries. Other factors are believed to play a role, including the amount of sugar in the diet, oral hygiene, and the composition and flow rates of saliva (63).

2.2.2.3 Current model of causation in Baby-bottle Tooth Decay:

Baby-bottle Tooth Decay was originally named for its association with certain feeding practices involving the bottle. The condition has subsequently been identified in children who were exclusively breastfed so many people prefer the term nursing caries. As association does not imply causality, it is unfortunate that this condition acquired such definitive names. The names imply causality, temporality and even a dose-response relationship. All children are either breast- or bottle-fed, but it is believed that only those children whose parents abuse these methods will be affected. The name Baby-bottle Tooth Decay has effectively blocked consideration of all other potential causes of this condition.

Baby-bottle Tooth Decay is believed to be caused by "improper parenting" (42): "overindulgence or lack of parental restraint" (64); "inconsistent and inattentive childrearing" (65); and "feeding abuse" (66). "Non-nutritive sucking" such as nap/bed-time feeding, prolonged bottle or breast feeding (beyond the age of one year), or using sweetened comforters (bottles or soothers), is thought to result in Baby-bottle Tooth Decay in the presence of bacteria and teeth (42).

2.2.2.4 Critical appraisal of Baby-bottle Tooth Decay causal hypothesis:

A causal hypothesis such as this should explain a significant amount of the variation in the distribution of the disease and should have high predictive value. A differential diagnosis should not require knowledge of exposure if the condition's existence as a disease entity is defined based on exposure. Infectious diseases should have an element of susceptibility. In the case of Baby-bottle Tooth Decay, these conditions are not met.

Many studies and most clinicians focus only on affected children and what strikes them most is the amount of time these children seem to have the bottle in their mouths. Of course, this is only one half of a statistic. In order to attribute any significance to this fact, it is important to know the prevalence of this practice among the unaffected to determine if an association even exists. A review of the literature has revealed that the association with feeding practices is inconsistent and varies greatly in strength. Many cases were not exposed to these risks and the vast majority of non-cases were exposed to these risks. One well-designed study (67) in California found that 90% of all children, affected and unaffected, were still using the bottle at 18 months of age. Ninety-one percent of the cases and 84% of the controls were still taking bedtime bottles at 18 months old. In two studies, although most of the affected children had had sweetened comforters, no more than 9% to 12% of all the children who had sweetened comforters went on to develop Baby-bottle Tooth Decay (56, 68).

The literature did reveal a strong and consistent association with socioeconomic status, as inferred from a variety of measures. Most commonly, studies recorded education levels in order to plan education material aimed at the correct level. A British study found that for children of the same socioeconomic status, the caries rate was almost twice as high for those with sweetened comforters. However, for children receiving sweetened comforters, the rate was more than three times as high for those of the lower socioeconomic status (69).

The differential diagnosis is difficult, which leads to the question as to whether or not the condition Baby-bottle Tooth Decay is meaningful. The condition is characterized by smooth surface lesions on most of the anterior teeth (surfaces not usually liable to decay) and occlusal lesions on the first molars. A condition with a similar appearance is known as rampant caries and is usually ascribed when the mandibular incisors are involved or when there is no exposure to risk behaviour (42). In describing a study that used clinical appearance and a history of the child's nursing habits in the diagnosis, Ripa states:

> This is important since others have made the observation that not all rampant caries in preschool children can be classified as nursing caries, and, therefore, an appropriate diet history and review of feeding practices may be necessary for a definitive diagnosis (42:274).

Also, if an underlying disease condition that is associated with increased caries is known to exist, Baby-bottle Tooth Decay is not identified as such, despite the similar appearance.

Teeth are sometimes reported as having been rotten upon eruption (64, 70). Even if the decay began with eruption it is hard to imagine how the feeding practices could have been so excessive as to cause decay so quickly. Some children are diagnosed with Baby-bottle Tooth Decay before the age of one (44). There is evidence that the future decay rate in teeth that are unerupted at weaning is higher in children with Baby-bottle Tooth Decay (71, 72). The bottle and breast feeding habits cannot cause this decay.

The association with feeding practices could be merely a measure of increased exposure. All of the identified risky feeding practices have the effect of increasing exposure to sugar, including lactose (the sugar in milk), relative to children who feed less often. This may be especially significant at naptime as the saliva rate is reduced; thus any cleansing and buffering action that might protect the teeth from caries is reduced. Of the implicated feeding practices, the association with nap/bed-time bottles is most consistent.

2.2.2.5 Going beyond the current model: a role for host susceptibility:

The epidemiological model for infectious diseases involves factors of the environment, agent and host. Infection depends on exposure to a source of infection and on susceptibility of the host (73). Microbiological studies have found widespread, almost ubiquitous, infection with bacteria associated with caries. Similar microflora have been found in people with and without caries, and in carious and non-carious areas of the mouth in individuals (74). The general model of infectious disease holds that, in the presence of infection, development of disease depends largely on factors intrinsic to the host (73). Applied to caries, the sugar-containing environment of the mouth is conducive to colonization by the bacterial agents. Infection may or may not lead to disease. Potential host factors, such as susceptible teeth, are ignored in this model. A recent review that concluded there is a need to reconsider several paradigms about the nature of dental caries has a section called 'Tooth Susceptibility ("the Host") (63). The focus on the concept of caries-resistant teeth is considered passé as "such a thing as relative resistance of enamel to caries attack does not exist" (63). It was proposed that the oral environment may modify the structural and chemical properties of teeth (63), but there is no consideration of developmental susceptibility.

The deciduous teeth are formed *in utero* and in early life. It is certainly recognized within the dental literature that defective teeth are more susceptible to decay (75). However, the knowledge as to what might constitute defective teeth is sparse. Gross hypoplasia is recognized but relatively rare even in populations with extensive decay. Still, it is consistently associated with higher rates of decay (76). Gross hypoplasia is generally attributed to disease or nutritional deficiency or toxicity during tooth development (76). Teeth with less obvious defects might exist and also be more subject to decay.

Early this century, Lady May Mellanby found precisely this, as well as demonstrating the importance of vitamin D in the presence of a diet adequate in calcium (37, 77-82). Her studies began with animal experiments and "fat soluble vitamin A," later identified as vitamin D. She found that she could produce defects in the teeth and jaws of puppies with a deficiency of this vitamin. Deficiencies of vitamin D led to calcification defects in the dentine and enamel and poor secondary dentine formation. These experiments led to histological studies of teeth from humans, and later to experimental studies involving different diet supplements for children living in institutions. Her studies are thorough, well controlled and explained in great detail. She presents all of her results with caution and always discusses limitations.

Institutionalized children who were in the study institutions providing cod liver oil supplements had less caries progression and more arrested caries. Later studies compared children in institutions receiving vitamin D in olive oil supplements compared to children in institutions receiving unfortified olive oil supplements, with the same conclusions. In those studies, Mellanby recognized the importance of interactions between foodstuffs, especially the importance of calcium, phosphorous, and certain phytate-containing cereals that interfere with calcium absorption. In the institutions studied, the children were receiving 1 g of calcium per day, which would still be considered ideal, and is more than was, and is, in the diet of most children and adults.

Based on Mellanby's work, the Committee for the Investigation of Dental Disease, of the Medical Research Council of Britain, concluded:

> The investigations...show conclusively that a relatively high vitamin D content of food can do much to diminish the incidence of caries if the vitamin is given during the development of the teeth; that a beneficial effect may be obtained if the vitamin is given at a fairly late stage of development; and that even when it is given after eruption of the teeth, the onset and spread of caries is delayed (81).

Mellanby developed a measure of varying levels of hypoplasia that is applicable to teeth still in the mouth and that correlates well with histologic evidence of defective calcification. This measure was subsequently used successfully by other investigators (80). Mellanby found that, of 1500 shed human teeth, 78% of those with well-mineralized dentine were caries-free, while only 6% of those with very hypoplastic dentine were caries-free. Of these same teeth, extensive caries occurred in only 7.5% of the normal teeth, and 74% of the very hypoplastic teeth (78). Decades later, an unrelated study of macro- and microscopic defects of enamel found that Alaska and Greenland Natives have more of both types of enamel defects than American Whites (83). Undiagnosed defects in teeth may be common in populations that experience high rates of tooth decay.

The pattern of hypoplasia that Mellanby found was similar in distribution to that of Baby-bottle Tooth Decay. Mellanby also found an association with socioeconomic status (78). The Baby-bottle Tooth Decay pattern of decay coincides with the developmental stages of tooth formation dating to the time near birth. Most people have a neonatal line that can be found with a microscope. This line of hypocalcified enamel is believed to result from a short period of subclinical hypocalcemia that normally follows birth. It is possible that infants of vitamin D-deficient mothers have a more profound hypocalcemic phase resulting in significant defects, thus predisposing neonatal enamel to decay.

2.2.2.6 Evidence that ultraviolet light may have a role in caries:

Recently, in Alberta, the introduction of full spectrum light in grade 5 classrooms led to significantly lower caries incidence in the permanent teeth of children exposed to the ultraviolet light compared to controls over a 22-month period (84). The authors do not ascribe this benefit to the endogenous production of vitamin D that results from exposure of skin to ultraviolet light or suggest another mechanism by which the result might occur. Perhaps vitamin D might have a role in protection from caries after the teeth have formed. Experiments in animals found that ultraviolet radiation is associated with decreased caries incidence (84). Hargreaves reports that an inverse association between caries and sunlight exposure in humans was noted in 1965 (84). This line of evidence lends credence to the theory that vitamin D has a role in caries.

2.2.2.7 Extent of caries in children in Island Lake, northern Aboriginal communities and rural Manitoba:

In the Island Lake area, the six-year-old tooth decay rate is 1.5 times higher than the rate for northern Aboriginal communities, which is already 3 times higher than the rate for six-year-olds in rural Manitoba. In one Island Lake community, a study of all treaty-status 3-year-old children found that at least 77% of the children suffer from Baby-bottle Tooth Decay, and 47% have dental surgery under general anesthetic in Winnipeg (85). In 1992-93, in Manitoba, 1086 children required general anesthetic for dental work and a conservative estimate for treatment of nursing caries that year exceeded $2.5 million (85). The average number of decayed, missing, or filled teeth in 1990 for 6 year-old children in rural Manitoba was 2.34, compared to 8.4 for Aboriginal children in northern Manitoba, while the 1994 figure for the Island Lake community was 11.7 (86).

2.2.3 Relevance:

Because Baby-bottle Tooth Decay is so common among Aboriginal people in North America, if vitamin D deficiency has a role in Baby-bottle Tooth Decay, then vitamin D deficiency is likely to be prevalent among Aboriginal people and not just in the Aboriginal communities studied as part of this research. It seems likely that prevention of vitamin D deficiency during pregnancy would be less expensive than providing dental work under general anaesthesia to approximately half of the children as in one Island Lake community.

It is known that developmental factors affect tooth integrity, what is not known is whether or not large numbers of people are being affected in this way. Certainly, in North America, frank malnutrition is uncommon. It is not known whether widespread subclinical deficiencies exist and are causing unrecognized calcification defects that could predispose teeth to caries.

2.3 Literature pertaining to prevalence of deficiency

2.3.1 Vitamin D deficiency and rickets in the Island Lake area:

This area has the highest incidence of vitamin D-deficiency rickets in Manitoba (87). Forty of 48 cases seen in one Manitoba hospital between 1972 and 1984 were Aboriginal: 18 were from Island Lake and 22 were from 18 other communities (87). Twelve cases were identified from this area in the year preceding a 1989 report (88).

In the first 5 ½ months of 1995, 12 cases of rickets were diagnosed in one Island Lake community (population 2,400, 100 births/year) (89). Actual rates are unknown; many cases are not diagnosed and only severe cases are evacuated to hospital (90). A 1974 study of the diets of preschool children found that 92% consumed less than the recommended amounts of vitamin D and 65% consumed less than the recommended amounts of calcium (91).

The reasons for the unequal distribution of rickets are unknown. Sunshine exposure may be limited by a more sedentary lifestyle than existed in the past and by the full clothing usually worn all summer. Milk is expensive and is not consumed in quantities that would meet nutrient requirements. However, these circumstances exist in other remote Aboriginal communities as well and recent research indicates that even casual exposure to sunlight is adequate. Thus, although many remote communities share the common risk factors associated with rickets (low socioeconomic status, nutritional deficiencies, high latitude), the factors which predispose the Island Lake area to rickets are unknown. The local use of the tikinagon (an infant carrier, the use of which involves swaddling) has been implicated in the reduced sun exposure of infants in Island Lake (92).

A 1987 study of 80 randomly selected mother-infant pairs from Island Lake found that 43% of infants and 76% of mothers had 25-hydroxyvitamin D levels below 25 nmol/L, the lower limit of the normal range used for this study (25 to 104 nmol/L) (92, 93). 'Normal' is not well defined. That study used a lower 'lower limit of normal' than this study (35 to 105 nmol/L); applying this higher value of the 'lower limit of normal' from the literature to the 1987 data changes the percentage of mothers below "normal" from 76% to 93%. Regardless of which level is used to indicate hypovitaminosis D, a biochemical measure of 25-hydroxyvitamin D status that was assessed for blood samples taken during June and July when ultraviolet light was available indicated that the vast majority of mothers with children aged 3 to 24 months were vitamin D deficient (92, 93).

From the clinical experience of general physicians and pediatricians that practice in the study communities, it was expected that Garden Hill might have as many as 24 cases diagnosed each year (among children under two years of age, i.e., an estimated 12 cases per one-year cohort) and no cases of rickets (or very few) were expected from Norway House. St. Theresa Point was known to have rickets but it was unknown if the problem was as prevalent as in Garden Hill. Thus, a significant difference between Garden Hill and Norway House was predicted over a two-year time period.

Osteomalacia, the adult version of rickets, causes weakness and fatigue as well as muscle and bone pain, difficulty walking, and an irregular gait (6). One study found that osteomalacia in the mothers was not diagnosed until rickets was found in their infants despite several physician consultations regarding symptoms (10). Thus, the high rates of subclinical vitamin D deficiency in Island Lake may also mark the existence of unrecognized osteomalacia.

2.3.2 Vitamin D Deficiency in Other Aboriginal Communities:

Nutrition studies have consistently reported that the diet of Aboriginal people in Canada does not contain sufficient vitamin D and calcium to meet recommended intake levels. The study that found that in Garden Hill, 65% of children consumed less than the recommended amount of calcium and 92% consumed less than the recommended amount of vitamin D, also found that in Cross Lake, another remote Aboriginal community in Manitoba, 30% of the children consumed less that the recommended amount of calcium and 77% consumed insufficient vitamin D (91). One study of women and children in five northern Manitoba Aboriginal communities found that 40% of students and 52% of women consumed less than 70% of the recommended amounts of calcium (vitamin D was not assessed) (94).

A study of nutrient intakes and food consumption patterns in mothers and school children was conducted in two communities in Northern Alberta, one with a school lunch program and one without (95, 96). In the community without the lunch program, 64% of mothers and 71% of children had calcium intakes less than two-thirds the recommended levels, and 36% of mothers and 44% of children had vitamin D intakes below two-thirds of the recommended level. The corresponding values for the community with the lunch program were 56% and 34% for calcium and 44% and 0% for vitamin D (96). Another Alberta study found that adult nutrient intakes were likely to be inadequate for 59% of the sample for calcium and 20% for vitamin D (97).

A dietary survey of women of child-bearing age, preschool children and older adults in three Manitoba communities found probability estimates of inadequate intakes for calcium of: 21%, 36%, 56%, 67%, 87%, 89% for children under 2 years of age, children between 2 and 4 years, women 16 to 24 years, women 25 to 45 years, women 56 to 74 years, and men 56 to 74 years, respectively (vitamin D was not assessed) (98). In Igloolik, Northwest Territories, the mean daily intakes did not meet the Canadian Dietary Standards for vitamin D for children 1 to 3 years old, and for calcium for children 4 to 6 years old (99).

The Indian Survey Report prepared by Nutrition Canada in 1975 was intended to study a stratified random sample of Aboriginal people across Canada but met with very high non-participation rates (88). None of the Island Lake communities were selected for sampling. Fully 71.2% of pregnant women had an inadequate calcium intake (less than 700 mg per day) compared to 26.8% of the national sample, and

71.3% had vitamin D intakes of less than 150 IU per day (less than 40% of the recommended daily allowance) compared to 29.8% of the national sample (100). This survey did not measure serum vitamin D metabolites.

Although dietary intake studies are complicated by the high variability in eating patterns, as well as the difficulty in quantifying serving sizes and calculating nutrient intakes, the evidence consistently suggests that Aboriginal people consume less calcium and vitamin D than other Canadians. In 1978, Dilling and colleagues suggested that "[s]ubclinical vitamin D deficiency may be a widespread problem in Indian communities and this should be investigated" (101). The hypothesis that vitamin D deficiency is prevalent in Norway House (the study comparison community) despite the absence of rickets stems from the hypothesis that vitamin D deficiency underlies Baby-bottle Tooth Decay. Baby-bottle Tooth Decay is prevalent in Aboriginal populations including Norway House. If vitamin D deficiency has a role in Baby-bottle Tooth Decay then this deficiency is likely to be widespread. The hypothesis that Norway House has vitamin D deficiency is also supported by the diet and nutrition literature indicating low calcium and vitamin D consumption among Aboriginal people and the laboratory science evidence that habitual low calcium consumption may lead to vitamin D deficiency. Thus it is hypothesized that vitamin D deficiency may be widespread in areas such as Norway House where it is not expected due to the lack of reported rickets.

2.3.3 Vitamin D deficiency in the general population:

Very little is known about the vitamin D status of the general population and very little research has pursued the link between vitamin D and other conditions with the exception of osteoporosis in the elderly. Perhaps this is because vitamin D deficiency is not thought to be a significant problem in North America. Also, it is not known if low 25-hydroxyvitamin D levels alone are harmful (102). The vitamin D status of the vast majority of people is unknown and assumed to be normal in the absence of florid disease (rickets, osteomalacia, and more recently, osteoporosis). Habitual low calcium consumption may lead to subclinical vitamin D deficiency, and vitamin D deficiency may have a role in Baby-bottle Tooth Decay (and other common diseases as proposed in Section 9). Widespread deficiency may be of great significance. If so, much could be gained from prevention efforts.

A review of 117 reports of vitamin D status (34 of the elderly, 42 of young adults, and 41 of both elderly and young adults) from North America, Scandinavia, and Central and Western Europe found wide variation and concluded that all countries should adopt a vitamin D-fortification policy (103). A recent study of the vitamin and mineral status of women of childbearing age in the United States found that women living in the greatest poverty (131% or more below the poverty line) were most likely to consume insufficient quantities of all vitamins and minerals (104). More surprisingly, the study found that the majority of women living furthest from poverty (at least 300% above the poverty line) also had intakes below the recommended daily allowance for several vitamins and minerals, including calcium (104).

A population survey of the vitamin D concentrations in two-year-old Indian-Asian children living in England found that between 20% and 34% of children in the three Asian ethnic groups had serum levels below 25 nmol/L (105). They compared this to 0% among children aged 1.5 to 2.5 years that took part in a national diet and nutrition survey (105).

A recent study reported in the New England Journal of Medicine found that 57% of inpatients in a general medical ward in Boston had vitamin D deficiency (106). This report prompted a letter that reported the results of a U.S population-based study (Third National Health and Nutrition Examination Survey (NHANES III, 1988 to 1994)), that found 9% of 15,778 noninstitutionalized adults had serum 25-hydroxyvitamin D levels less than or equal to 15 ng per millilitre (107). For those people at latitudes similar to Boston, 13% had vitamin D deficiency when studied in September (107), a time that should coincide with seasonal peaks for 25-hydroxyvitamin D concentrations at that latitude. The authors of the inpatient study concluded that the differences in the reported prevalence of vitamin D deficiency were not important. What is important is the fact that a significant proportion of normal adults and an even higher proportion of hospitalized adults have vitamin D deficiency (108).

3. OBJECTIVES

3.1 To determine incidence rates of clinical rickets in young children for Garden Hill, St. Theresa Point and Norway House.

3.2 To determine prevalence rates of prenatal maternal vitamin D deficiency for Garden Hill, St. Theresa Point and Norway House.

3.3 To determine the presence and strength of potentially etiologic factors for vitamin D deficiency and rickets that differ between Island Lake and Norway House.

3.4 To determine the amenability of risk factors for prevention of vitamin D deficiency and rickets.

4. HYPOTHESES

4.1 The incidence rate of clinical rickets is significantly higher in the Island Lake area (Garden Hill and St. Theresa Point) than in Norway House, the comparison community.

4.2 Vitamin D deficiency is widespread among pregnant women in all three communities but the extent and magnitude are greater in the Island Lake area.

4.3 The prevalence of risk factors for vitamin D deficiency among pregnant women is higher in the Island Lake area compared to Norway House.

5. THEORETICAL FRAMEWORK & METHODOLOGY

As the focus of epidemiology has broadened from disease to include health, and the definition of health has widened from the absence of disease to one of well-being, many types of influences on health, from biological to social, have been identified.

> [T]he health of any human population is the product of a complex web of physiological, psychological, spiritual, historical, sociological, cultural, economic, and environmental factors (109):3.

Also:

> [b]ehaviour is seen increasingly not as isolated acts under the autonomous control of the individual, but rather as socially conditioned, culturally embedded, economically constrained patterns of living (110):12.

A study that takes into account the contribution of social and cultural factors in health and illness will be better able to understand the multiple determinants of illness and to identify potential avenues for effective prevention. This study, designed to study the reasons for the high frequency of vitamin D deficiency in the Island Lake area of Manitoba, was based on a conceptual framework that included these factors.

5.1 Social and Cultural Issues and Health:

There are both proximal social factors (e.g., family, work organization, school, neighbourhood, and community) and distal social factors (e.g., political economy, social stratification, and systems of gender, race and ethnic relations) that can influence health (111). Many cultural factors can influence health and illness (e.g., family structure, gender roles, marriage patterns, pregnancy and childbirth practices, child-rearing practices, diet, dress, and self-treatment strategies and lay therapies) (112).

Social factors also affect health behaviour (e.g., resources, availability of services, and peer pressure), as do cultural factors (e.g., perception of symptoms, utilization of health care, adherence to therapies, and response to health promotion programs) (111). Frequently, several social and cultural factors coincide, such as economic status, occupation, use of 'chemical comforters' and dietary preferences (112).

There is ample evidence from the literature in social epidemiology, medical anthropology and medical sociology, as well as that pertaining to Aboriginal health, that social and cultural issues are important to health although their role in determining health status is poorly understood. Health care workers need to understand how people interpret and manage their health and illness to "negotiate" effective efforts for prevention and control (113:324).

"Socioeconomic status is the most powerful and consistent epidemiological risk factor" (114:214). Yet, traditional epidemiologic methods cannot explain the substantial variation in health and health care patterns across Canada (109:259). The perspectives and concerns of Aboriginal people are needed to understand the basis for health and disease in individual communities (109:259). Culture is dynamic. Garro found that the way the Anishinaabeg "...interpret and respond to illness is a product of both past and present, of continuity and change" (115:419). For Aboriginal people in Canada, erosion of the traditional resource base has lead to high unemployment and an increased dependency on government assistance (116). Indicators of living conditions and health are consistently worse for Aboriginal people than for other Canadians (109, 117, 118).

Cultural influences may play a role in nutritional problems: they may exclude required nutrients; they may promote consumption of injurious products; they underlie beliefs about body image and function, and the role of diet in health and disease (112). "However it should always be remembered that cultural influences alone *do not* account for the vast majority of malnutrition worldwide - though they may be one of the factors contributing towards it. To be fully understood, malnutrition should always be placed in its wider social, political, economic and environmental context" (112:50). "In many cases of malnutrition, therefore, the causes lie outside the control of the individuals, their families and their communities" (112:51).

Cultural factors, "where they can be identified, are often difficult to quantify...nor is there a neat, measurable 'dose-response relationship'...[their] role is contributory, rather than directly causative (112:321). Thus, cultural factors may contribute to, or protect against, ill-health.

> In many of these [developing] countries, much of the population, already weakened by poor nutrition, will suffer from infectious and other communicable diseases. These diseases are often transmitted with the help of polluted water supplies, poor sanitation and inadequate housing, all of which can be improved by an adequate income. Therefore at the macro level these types of economic and social factors - as well as the political organization of the society - must always be taken into account, before considering the exact role of cultural factors in health and illness (112:320).

The social factors linked to nutritional problems generally relate to poverty (e.g., deprivation, access, and distribution) but it is difficult to ascribe causality to them. The role of poverty is not well understood despite extensive research. This may be because the role varies between situations, but may also reflect incomparable methodologies. Poverty, like socioeconomic status in general, is usually defined by a small number of easily measured variables that may not have explanatory power on their own.

Past efforts to address vitamin D deficiency in the Island Lake area have not been successful. Consideration of social and cultural factors has been minimal and did not involve input from the local people themselves. In order to improve the likelihood of developing successful, sustainable, ways to address vitamin D deficiency, this research was designed to include Aboriginal people and to collect information from community members so as to better understand the role of social and cultural factors influencing vitamin D status.

5.2 PRECEDE-PROCEED:

A health promotion framework was chosen for its ability to support multi-method research and include a focus on social and cultural factors as well as community participation to guide the development of appropriate action. The health promotion planning and evaluation framework of the PRECEDE- PROCEED model of Green & Kreuter (see Figure 2) guided this multi-method study (110).

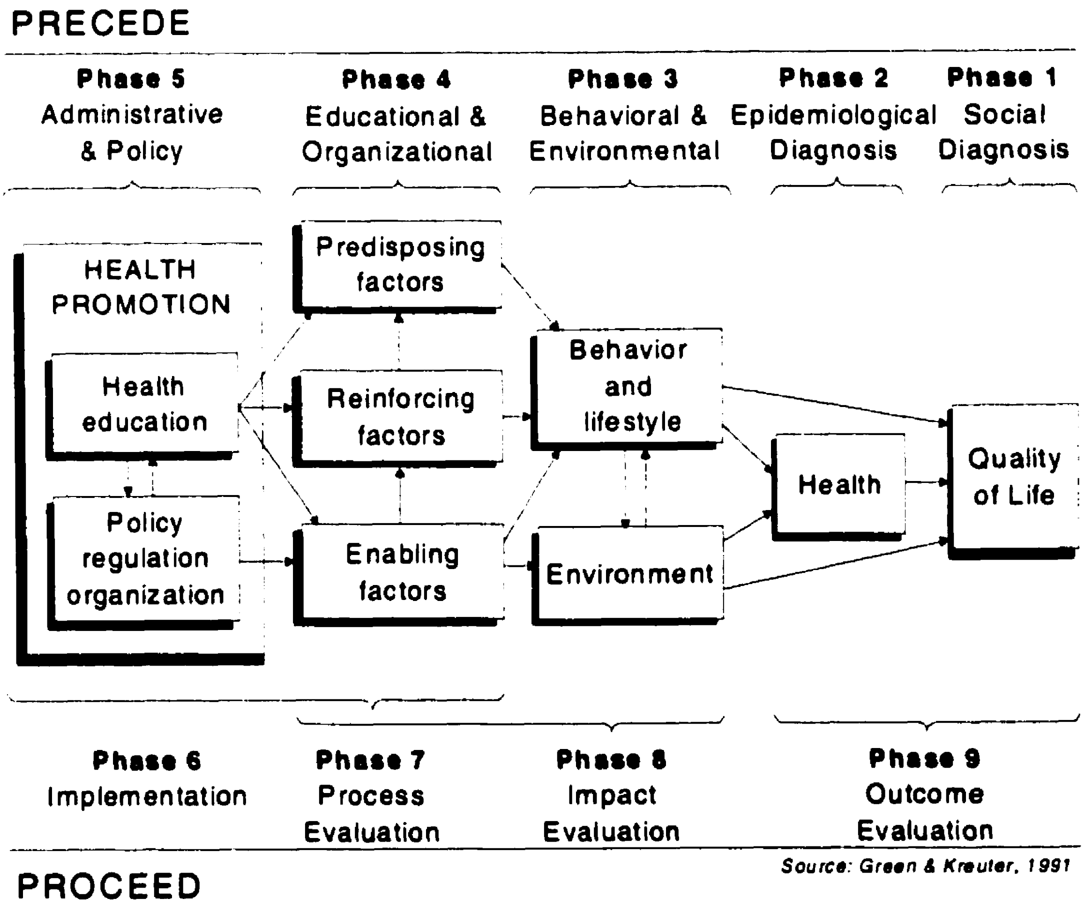

Figure 2: PRECEDE-PROCEED Model for Health Promotion Planning and Evaluation.

PRECEDE stands for predisposing, reinforcing, and enabling constructs in educational diagnosis and evaluation, and represents the 1980 framework that has since been multiply tested and validated. PROCEED stands for policy, regulatory, and organizational constructs in educational and environmental development, and comprises the 1991 addition superimposed on the model to address the broader mandate of health promotion that has developed since that time (110).

> PRECEDE assures that a program will be appropriate to a person's or population's need and circumstances. PROCEED assures that the program will be available, accessible, acceptable, and accountable...PROCEED assesses resources required to assure the program's availability, organizational changes required to assure its accessibility, and political and regulatory changes required to assure its acceptability. Finally, evaluation assures that the program will be accountable to policy makers, administrators, consumers or clients, and any other stakeholders...(110:209).

Green and Kreuter focus on behaviour change in individuals as is consistent with the goals of current health promotion efforts. However, the model provides for a much broader focus on social determinants and the possibility that advocacy for systemic change may be the best approach, as advanced by participatory action researchers. Green and Kreuter emphasize the importance of the principle of participation. Involving community members "...provides the opportunity for ownership, which can lead to a sense of empowerment and self-determination - those difficult-to-measure intangibles that so often make the difference between long-term success and failure" (110:269). Green and Kreuter "...do not ignore the larger tasks of social change and policy advocacy that each health professional should seek to support" (110:13).

5.3 Methodology: PRECEDE-PROCEED applied to vitamin D deficiency:

Using data collected in Garden Hill and St. Theresa Point in the Island Lake area and Norway House as a comparison community, this research applied only some of the steps in the PRECEDE-PROCEED model. Application of the full model was beyond the scope of this dissertation project, and will require substantial effort at the community and policy-making level. The results of this study will be supplied to the community leaders and health care providers and will include recommendations for future research and action.

In the social diagnosis phase, the community should be engaged as an active partner and the needs assessment should focus on quality of life and priorities. Quality of life is gauged by the subjective perceptions of local people regarding problems and priorities, and the collection of social indicators such as unemployment, housing density, and social assistance rates. Although this research began with an outside impetus and was led by a non-Aboriginal researcher, community members from Garden Hill were included from the early stages. This allowed consideration of local concerns and their incorporation into the planning of the study. Garden Hill was selected as the focus for community participation because it was the community known to health care providers as having the greatest rickets problem. A Rickets Committee was designed to act as a "focal point for community participation" (110). Cultural factors such as beliefs and values concerning diet (milk, other relevant foods), sun exposure, health and an individual's ability to acquire good health were sought using key informant interviews. Some of the social diagnosis data (including the verification and documentation of concerns) was identified during the systematic data collection.

Although the next step was not a part of this research project, Green and Kreuter (110) recommend expedient use of existing information whenever possible (archival sources, relevant health literature, data from agencies). Still, should the community or those responsible for health promotion or health care services wish to apply the PRECEDE-PROCEED model in its entirety, the results of this study will become part of the existing information when they are disseminated to the community leadership, healthcare providers, and the public. Other sources of information include recent needs assessments conducted as part of the transfer of authority for health services to Aboriginal people. The Band Council and Medical Services Branch have demographic and health information that would be valuable.

The second phase of the PRECEDE-PROCEED model is epidemiological diagnosis, and can take two forms: the reductionist approach, that starts with a broad social problem, or the expansionist approach, that starts with specific health problem. This research took the latter approach, as vitamin D deficiency was identified *a priori* as the target, and addressed all of the elements of epidemiologic diagnosis set forth in the PRECEDE-PROCEED model (110).

Local data pertaining to vitamin D deficiency and rickets was interpreted in light of medical and epidemiological knowledge regarding cause & effect relationships and with respect to the experience of this problem outside this area. Indicators of health status (i.e., incidence of rickets, and prevalence of vitamin D deficiency in pregnant women) were collected from medical records and serum analyses as part of this study. Information about the presence and level of risk factors (sun exposure, vitamin usage, relevant dietary data (such as that for milk and other calcium-containing foods)) in the community was gathered as part of the systematic data collection. Measures of association were assessed using statistical methods. The results will be useful for setting priorities consistent with social realities and cultural priorities.

The third phase of the model pertains to behavioural and environmental diagnosis. The components of this phase were addressed in this research. Green and Kreuter recommend "...concentrating on those aspects of the environment that are: (1) more social than physical (e.g., organizational and economic), (2) interactive with behaviour in their impact on health, and (3) can be changed by social action and health policy" (110:142).

Behavioural and environmental factors relevant to vitamin D deficiency were sought through a variety of methods including conversations with community members, health professionals, store and agency staff, key-informant interviews, interviews with study participants, and collecting data on local prices and availability of relevant foods. The questionnaire was developed to assess these factors in terms of importance and changeability. Behavioural diagnosis included a focus on sun exposure, vitamin usage, and consumption of vitamin D and calcium containing foods. Environmental diagnosis included economic, physical, social, and service factors, such as affordability and accessibility of relevant foods, encouragement and supply of vitamins to pregnant women and babies, sun sensitivity and lactose intolerance.

The fourth phase of the PRECEDE-PROCEED model entails educational and organizational diagnosis and focuses on three categories of factors that collectively affect individual or collective behaviour: a) predisposing factors (antecedents: rationale, motivation); b) enabling factors (antecedents: enable motive realization); and c) reinforcing factors (subsequent: reward) (110). This research was designed to identify these factors that were then sorted according to whether they are positive, which can be built on, or negative, which need to be overcome.

Administrative and policy diagnosis comprise phase five of the PRECEDE-PROCEED model. Administrative diagnosis includes information about the current state of affairs as well as needs for success, and potential barriers. This study does not address these issues in great detail. The options for prevention that are discussed do include certain considerations relevant to administration and policy. For example, healthcare workers in these communities are very busy and this study had resources for this dissertation research project only. Whatever strategies are developed, health education and training will be required. Policy considerations focus on the support of the Band Council and the healthcare system to end rickets, the current high dose supplement program for pregnant women, the potential for community organization and policy related to store practices (especially in the Band stores), or to subsidies or price control programs. These factors will be among those that need to be considered when planning prevention, which is outside the scope of this study.

Phases six to nine of the PRECEDE-PROCEED model include: implementation; process evaluation; impact evaluation; and outcome evaluation. These latter four stages were not part of this research. Information needed for evaluation of any future interventions was collected during this study. Even without further application of the PRECEDE-PROCEED model, this research will support further research and prevention planning.

6. METHODS

6.1 Ethics:

Prior to conduct, this research was approved by the University of Manitoba, College of Medicine, Faculty Committee on the Use of Human Subjects in Research, as well as by the Island Lake Tribal Council, and the Chiefs and Councils of Garden Hill, St. Theresa Point, and Norway House.

6.2 Rickets incidence:

A historical prospective study of the incidence of clinical rickets in treaty-status Aboriginal children born in 1993 and 1994 (a retrospective chart review of birth cohorts from Garden Hill, St. Theresa Point, and Norway House) was conducted. Because the provision of all health services in these remote Aboriginal communities was through the one Medical Services Branch nursing station or hospital in each community, it is likely that all births to women living in these communities were captured by the local system. In Norway House, women give birth at the hospital; in Garden Hill and St. Theresa Point, nursing station staff are responsible for arranging the evacuation of all pregnant women to hospital for childbirth. A two-year sample was expected to include approximately 200 children from each community. As rickets is usually diagnosed within the first two years of life, children born in 1993 and 1994 were old enough to have developed rickets by the time the medical record review began in June 1996.

A cohort of all treaty-status children was established from available sources in each community. From that sampling frame, children with incomplete charts and those with insufficient information to identify them (missing name or treaty number) were excluded, along with children who were deceased, adopted out of the community, or had treaty numbers from other communities and no medical files. The remaining unique individuals made up the target study population. Of this target group, charts that could not be located were considered lost to follow-up, and excluded from the analysis.

In Garden Hill, the names, birthdates and treaty numbers of children born in 1993 and 1994 were abstracted from the "Birth Book" kept by the Nursing Station staff. In addition, the public health nurse provided an emergency list prepared to assist evacuation in the event of a forest fire. This list included children born in 1993. No such list existed that included children born in 1994. In Garden Hill, the December 31, 1995 band list was also checked for individuals born in 1993 and 1994. In St. Theresa Point, the Nursing Station maintains a file by month and year with every new birth added to the file. In Norway House, the health records staff at the hospital provided a copy of birth lists maintained in an immunization database. Medical records of every child with a treaty number born in 1993 and 1994 were sought, and those found were searched by the author for evidence of clinical rickets.

For the purposes of this study, a clinical rickets case was counted if a medical chart contained a diagnosis of rickets and evidence that clinical signs of rickets preceded this diagnosis, or if the signs of rickets were treated with high-dose vitamin D supplementation and evidence of clinical signs preceded the treatment. This latter definition arose due to the non-standardized nature of the medical records. Two cases were counted that did not record a rickets diagnosis. These children were diagnosed as ?rickets due to clinical signs, treated for rickets (100,000 IU vitamin D), and followed up by pediatricians. Clinical signs for a case included frontal bossing, rachitic rosary, bowed legs or arms, swollen wrists or ankles, seizures, tetany, layngospasm, cardiorespiratory failure, myocardiopathy, delayed motor development, abnormal gait, or hypotonia, and needed to precede a diagnosis of rickets. Information was collected on children with biochemical rickets and those with clinical signs suggestive of rickets in the absence of a specific diagnosis (or treatment and follow-up as mentioned above) but these children were not included in the calculation of rickets incidence. Medical records following the diagnosis were searched to identify and exclude cases due to hereditary or other pathological conditions (prematurity, prolonged jaundice, chronic liver disease) and not due to "nutritional" rickets. An *a priori* decision was made to exclude fortuitous diagnoses resulting from biochemical and radiological tests done for unrelated symptoms, or due to subjective assessments of high risk. The potential exists for a detection bias resulting from heightened awareness of rickets among health professionals in the Island Lake area. Because this bias could have lead to more biochemically-identified rickets cases in the Island Lake area, these cases were not included in the case definition. The one case of biochemical rickets found was recorded but excluded from the clinical rickets case count, the incidence rate, and the inter-community comparison.

The medical record review was time-consuming and not a simple matter of checking for a diagnosis on a problem sheet. The entire chart was perused for indications of anything that suggests or accompanies rickets including references to seizures and other nutritional/developmental deficiencies such as anemia and failure-to-thrive. The section that contains laboratory reports was searched for evidence of alkaline phosphatase and vitamin D analyses. Because children suspected of having rickets are often or always referred to the pediatrician when they are in the community, letters in the file were scanned for any references to vitamin D and rickets.

Incidence rates were calculated for the two-year period for each community. The numerator was the number of clinical rickets cases (as defined above) found over the two-year period in each community. The denominator was the number of charts reviewed. Incidence of clinical rickets was compared between the pairs of communities using the chi-square test (with Yates correction for 1 degree of freedom). This allowed comparison of the number of observed cases to the number expected if there were no differences between any two of the communities.

6.3 Prevalence of vitamin D deficiency among pregnant women:

A cross-sectional serum survey was conducted to establish levels of biochemical indicators important in vitamin D metabolism and to determine the prevalence of VDD in pregnant women. The serum levels of 25-hydroxyvitamin D (25(OH)D), alkaline phosphatase, calcium, and phosphate were measured in blood samples taken from pregnant women who agreed to take part in the study. The power to detect a significant difference in prevalence between Garden Hill and Norway House was assessed *a priori* using: the sample size calculated; an expected 76% prevalence of deficiency in Garden Hill (based on results of a previous study) (3); and an estimated 55% prevalence of deficiency in Norway House (based on the expectation of deficiency from the literature in conjunction with the lack of an apparent rickets problem) (see Appendix 2).

When a woman was identified as being pregnant she was invited by the nurse or doctor to attend a prenatal clinic. At that time, all pregnant women received standard routine prenatal care. It was during this visit that each woman was asked by the nurse or doctor if she would be interested in taking part in this study. Information about the study was provided to the woman and signed consent forms were collected for those who agreed to participate. Blood samples for this study were requisitioned along with routine prenatal blood analyses and the blood samples were taken at the same time. In Garden Hill and St. Theresa Point where an oral high-dose vitamin D supplementation program is part of current clinical practice for all pregnant women, blood was collected before the supplement was given. A reminder for nurses to take blood before giving the vitamin supplement was placed on all of the vitamin D containers in the nursing station prior to data collection. Study samples were shipped to the Clinical Chemistry Laboratory at the Health Sciences Centre in Winnipeg for analysis.

Serum calcium was analyzed using the Boehringer Mannheim Systems 1 551 272 and 1 730 240 laboratory test kit. Serum phosphate was analyzed using Boehringer Mannheim Systems 1 551 388 and 1 730 347 laboratory test kit. Serum alkaline phosphatase was analyzed using BM/Hitachi 917 System Pack 1 557 033 laboratory test kit. Serum concentration of 25-hydroxyvitamin D was analyzed using the laboratory test kit INCSTAR 125I 25-OH Vitamin D RIA Kit insert, Cat # 68100.

Appendices 3, 4, and 5 contain information on the laboratory test kits, normal values, and verification tests, conducted by the Clinical Chemistry Laboratory of the Health Sciences Centre.

Prior to data collection for this study, in February 1996, the Health Sciences Centre laboratory evaluated the INCSTAR kit against the HPLC analysis performed by the Mayo Clinic Laboratories. Prior to this, samples were shipped to the Mayo Clinic Laboratories for 25-hydroxyvitamin D analysis. The INCSTAR kit results correlated well with the Mayo HPLC method for total 25-hydroxyvitamin D. Based on 22 samples, a correlation of about 90% was found (see Appendix 4). One outlier in the laboratory verification study was removed from analysis. In that case, the Mayo Clinic Laboratory result was 120 nmol per litre, whereas the Health Sciences Centre results were 15 nmol per litre upon first extraction and 21 nmol per litre upon second extraction.

There was insufficient specimen to reassay again by either method. Four samples from this study were analyzed at the Mayo Clinic Laboratories and at the Health Sciences Centre using INCSTAR. Three results correlated very well whereas the fourth result from the Mayo Clinic Laboratory was 75 nmol per litre and the Health Sciences Laboratory result was 40 nmol per litre. When this latter sample was repeated twice at the Health Sciences Centre, the results were 43 and 49 nmol per litre. In addition to the four study specimens, three samples from laboratory staff and two other non-study samples were sent to the Mayo Clinic Laboratory in October 1998. Five of the 25-hydroxyvitamin D concentrations from the INCSTAR Kit are lower than concentrations found by the Mayo Clinic Laboratories. For the four specimens that had Mayo Clinic results below 40 nmol per litre, the correlation with INCSTAR results were very good (see Appendix 5). Stability of samples was not a problem, and the Health Sciences laboratory report concludes that they are confident that the results reflect the vitamin D status of the population studied (119).

In this study, subjects were enrolled until both blood samples and interviews were collected from a total of 35 women from each community or until the 12-month data collection period was complete. A sample size of 35 was calculated *a priori* using milk consumption as the covariate of primary interest (see Appendix 2). This was estimated to take approximately 7 months based on the birth rate and an 80% participation rate.

Blood collection began in all three communities at the same time of the year (October) to help control for seasonal differences in 25-hydroxyvitamin D levels. The plasma concentration of 25-hydroxyvitamin D reflects the dietary and endogenous supply of vitamin D. Subjects with a 25-hydroxyvitamin D value less than 35 nmol/L were identified as vitamin D-deficient, and prevalence rates were calculated for each area. The denominators were the numbers of women from each community for whom blood samples were analyzed for 25-hydroxyvitamin D concentrations as part of this study.

The 25-hydroxyvitamin D levels of the communities were compared to each other using non-parametric tests because the distribution was non-normal and did not meet the assumptions for a Student's *t* test. The Kruskal-Wallis test was used to test for significant differences among the three communities, as was the Median test. The Mann-Whitney *U* test was used to test for significant differences between the pairs of communities. The remaining serum parameters were assessed using univariate and multivariate analyses for their association with each other and with 25-hydroxyvitamin D concentrations.

6.4 Risk factors:

A cross-sectional survey was conducted to investigate environmental and personal risk factors for vitamin D deficiency among pregnant women, and the amenability of the risk factors to change for prevention. All of the study participants who agreed to provide blood samples agreed to be interviewed on the same informed-consent form.

A Garden Hill woman was hired as a community co-ordinator and interviewer. As the part-time doctor's assistant at the nursing station, and with prior experience conducting health research interviews, this research assistant was ideally situated to facilitate recruitment by reminding the nurses to invite women to participate in the study.

In St. Theresa Point, a local woman was hired on the basis of recommendations by healthcare workers at the nursing station. Although she did not have experience with research projects or conducting interviews, she was very keen and had tremendous support from a Community Health Representative and other staff at the nursing station. She was able to attend the nursing station on days when prenatal clinics were held and facilitate recruitment by reminding the nurses of the study. The woman hired in Norway House also attended prenatal clinics, and knows the staff at the Norway House hospital as she works as a casual Licensed Practical Nurse. All three interviewers were trained in one-on-one sessions as to how to conduct the interview, the purpose of the research, the rights of the women to withdraw or refuse to answer any questions, and the importance of consistency and accuracy.

After a woman was recruited to the study by the nurse or doctor and her blood was drawn for the study and routine prenatal work-up, her name and a copy of the consent form would be given to the local research assistant. The research assistant contacted the woman and made arrangements for an interview. The interviews were designed to occur in the home of the pregnant woman, but were conducted elsewhere when that was not acceptable.

In-depth, semi-structured interviews of ten key informants were used to aid questionnaire development (see Appendix 6). Key informants were women who were community members in Garden Hill and included one mother of a child with rickets, and one elder. Questionnaires, which included quantitative and qualitative items, collected sociodemographic, gestational, and dental health information, as well as sun exposure; dietary consumption of foods that contain vitamin D and calcium; the use of vitamins; and clinical signs of vitamin D deficiency. Appendix 7 contains copies of the information sheet provided to participants, the informed consent form, and the interview questionnaire. Perceptions of lactose tolerance, sun sensitivity, and the reasons for certain relevant practices were pursued using open-ended questions.

The questionnaire was developed with the input from the research assistant, a community health representative, and a volunteer from Garden Hill. The questionnaire was pilot tested by the research assistants in all three communities prior to use. Three pilot interviews were conducted in each community. Most women of childbearing age in all three communities speak and understand English. Thus, the questions were prepared in English. However, face-to-face interviews using the standardized questionnaire form were conducted by a local research assistant who was able to translate all portions verbally to the local language (Cree in Norway House and Island Lake Dialect in Garden Hill and St.Thersea Point).

The quantitative results were analyzed using SPSS software (120). Pearson's chi-square tests were used to determine which variables differed significantly between the communities. Non-parametric tests were used to compare groups by vitamin D status and independent variables: the Kruskal-Wallis test, Median test, and the Mann-Whitney *U* test for vitamin D status. Multiple logistic regression was used to attempt to identify risk factors that differ significantly between the communities and the odds ratios for these risk factors, adjusted for confounding variables. Multiple logistic regression was also used to attempt to assess the unique effect of the risk factors on the odds of being vitamin D-deficient, regardless of community. Multiple logistic regression was not successful due to limitations created by the homogeneity of the results from all three communities.

The qualitative results were analyzed for factors that influence the potential to intervene on risk factors. A grounded-theory approach to analysis and interpretation was taken, and oriented toward action and process (121). Data abstraction, reduction, and synthesis (aggregation of categories and the use of strategies for linking categories) were used; categories were not ascertained a priori but emerged from the data.

All the data were entered into a spreadsheet. All the responses for each specific question were viewed together. Patterns were identified and similar responses were grouped. Individual responses that were especially unique or unexpected were selected for direct quotation, as well as some that were representative of more than one response. Responses for multiple questions were viewed together by individual and by community for patterns or discrepancies. Responses were viewed by community, allowing patterns to emerge that may have implications for the type of prevention strategy selected and the efforts required for success.

Interpretation (theory development), which involved attaching meaning and significance to the analysis, was aided by input from the interviewers who are community members. Further community involvement will follow upon return of these results to the community for prevention planning.

The information from the questionnaires was used to illuminate the relationship between the risk factors and beliefs and practices. The potential amenability of risk factors for change was assessed and recommendations for prevention efforts were made. This synthesis of the qualitative and quantitative results included an assessment of the predisposing, enabling, and reinforcing factors that may affect the likelihood of success.

6.5 Participatory approach:

Because there was evidence of widespread vitamin D deficiency, reason to suspect that vitamin D deficiency may be associated with conditions other than rickets, and because rickets has caused serious health problems in a small fraction of children and is preventable, this research was proposed to the Island Lake Tribal Council in October of 1994. Chief and Council were interested in sustainable solutions. A participatory component was designed to increase the likelihood of making that happen. There was a lack of understanding of the reasons for persistent rickets in one area, despite periodic attempts to heighten awareness and promote vitamin and milk consumption. A Rickets Committee of Garden Hill community members was established to collaborate on the design, conduct and analysis of the study. This was designed to facilitate the two-way transfer of knowledge. Conversations with community members and local media events contributed to attempts to include and inform the community.

7. RESULTS

7.1 Rickets incidence:

In order to have accurate denominators and numerators for the incidence rates, it was important to create a cohort list that was as complete as possible and then to find as many of the medical charts for children in that cohort as possible. Charts were sought for all babies, but those found to be deceased, adopted out of the community, or with a treaty number from another community and no chart were excluded from the denominator. Charts containing too little information to determine whether or not they had rickets were also excluded; although two children had charts in the community they had not attended the clinic in years and had likely moved away. In addition, the names with too little information to find the charts were excluded. Most often this was due to a missing or erroneous treaty number. For example, the names of new babies are entered in the birth book as soon as news of a birth is received and the baby's name and treaty number are not always known at that time. Sometimes a young mother's treaty number is entered and, when the number changes later, the birth book is not updated. Children get their own treaty number when they turn eighteen years old, so the number will change for women who give birth before age 18. In the 88 entries in 1993 for Garden Hill, 30 had errors or omissions in the treaty number. This is significant because the treaty number is important for finding a chart. Interviews with the research assistant in Garden Hill were very helpful in resolving problems locating charts as she works in the nursing station and knows most of the families, their treaty numbers, and which ones have moved away. For those 88 babies, charts were located for all but 14: one had no treaty number; two had no baby names; one was adopted out of the community; the remaining ten were not located in the filing cabinets despite three separate attempts to find the charts. These children may have moved away or their files may have been temporarily located at another health care facility or in another location within the nursing station.

In Garden Hill, three sources for names were used. The second and third sources were searched for new names to add to the list created from the birth book, which was the primary source (the one kept by the nursing station as a list of all babies born). The sources used to construct the cohort lists and the proportion of charts located can be seen in Table 1. The proportion of charts actually found in the filing cabinets was highest for those children whose names were in the birth books.

Some of the children born to women who were living in these communities at the time of birth may never have lived in these communities themselves. The women are sent from Garden Hill and St. Theresa Point to communities with hospitals for childbirth and may take up residence there. Thus the medical charts for these children would be located elsewhere. Some may have moved away from the communities after birth but while still so young that there is no way to determine if they went on to develop rickets. In Garden Hill, the band list provided 20 new names but only 9 were in the files in the community. These other band members may live elsewhere, and the birth book is likely to be a better representation of the births to women who lived in the community during their pregnancies.

Because many of those whose charts were not located may not be long-term residents, their exclusion is likely to be appropriate and leaves a sample that probably better reflects the local situation. However, some of those children whose charts were not found may be among the sickest children, and their charts may have accompanied them to hospital. This may mean that the sample is biased and rickets cases may have been missed. Thus, calculating the rates based on a comparison of the number of cases found to the number of charts reviewed may be a conservative estimate of the incidence of clinical rickets in these cohorts. The incidence is expected to be an underestimate due to the likelihood that many affected children were never diagnosed, as is supported in the literature on rickets. Ten possible rickets cases were identified for whom a diagnosis of rickets was never made but signs of rickets were recorded.

Table 1: Data sources used to construct birth cohorts (and charts found by source).

		# unique individuals	# excluded*	# in cohort	# (%) found
GARDEN HILL:					
1993	Birth Book	88	4	84	74 (88)
	Fire List	21	2	19	12 (63)
	1995 Band List	7	0	7	1 (14)
1994	Birth Book	92	4	88	82 (93)
	1995 Band List	13	0	13	7 (54)
Total		**221**	**10**	**211**	**176 (83)**
ST. THERESA POINT:					
1993	Birth File Cards	69	14	55	44 (80)
1994	Birth File Cards	62	2	60	47 (78)
Total		**131**	**16**	**115**	**91 (79)**
NORWAY HOUSE:					
1993	Immunization File	99	0	99	99 (100)
1994	Immunization File	103	0	103	103 (100)
Total		**202**	**0**	**202**	**202 (100)**

*exclusions were for missing treaty numbers, adopted and deceased children, and those who have treaty numbers from other bands and did not have charts in the community.

The results of the medical record review are shown in Figures 3 to 5. In Norway House, there were 99 treaty-status babies (56 female and 43 male) born in 1993 and 103 (47 female and 56 male) born in 1994. This includes 11 with treaty numbers from other bands (Cross Lake, God's Lake, Bearspaw, Lower Mohawk, Valley River), and four who did not live in Norway House at the time of review. However, all of the 202 charts were reviewed. There were no cases of rickets identified.

In St. Theresa Point, there were 69 babies (35 female and 34 male) born in 1993 and 62 (35 female and 27 male) born in 1994. This includes four with treaty numbers from other bands (all were from Island Lake: Garden Hill and Wasagamack), but their medical records were not located in St. Theresa Point and so they could not be included. Another seven children (three that were deceased and four that were adopted out of the community) did not have a chart in St. Theresa Point. In addition, there was insufficient information to locate the charts of five children (e.g. the treaty number had not been recorded). Of the 115 charts sought, 24 could not be located. In all, 91 medical records from 1993 and 1994 were reviewed.

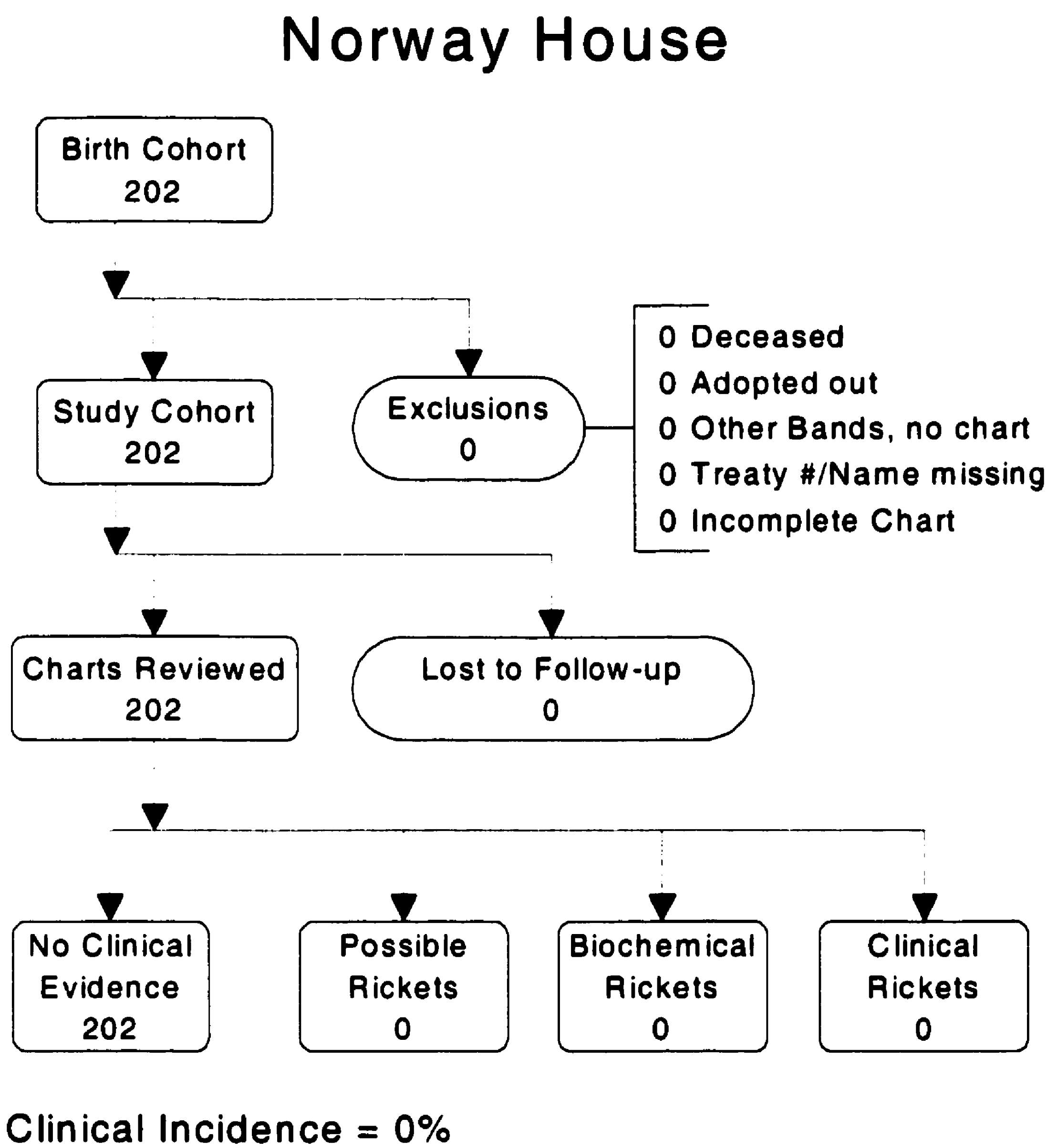

Figure 3: Results of the Medical Record Review in Norway House

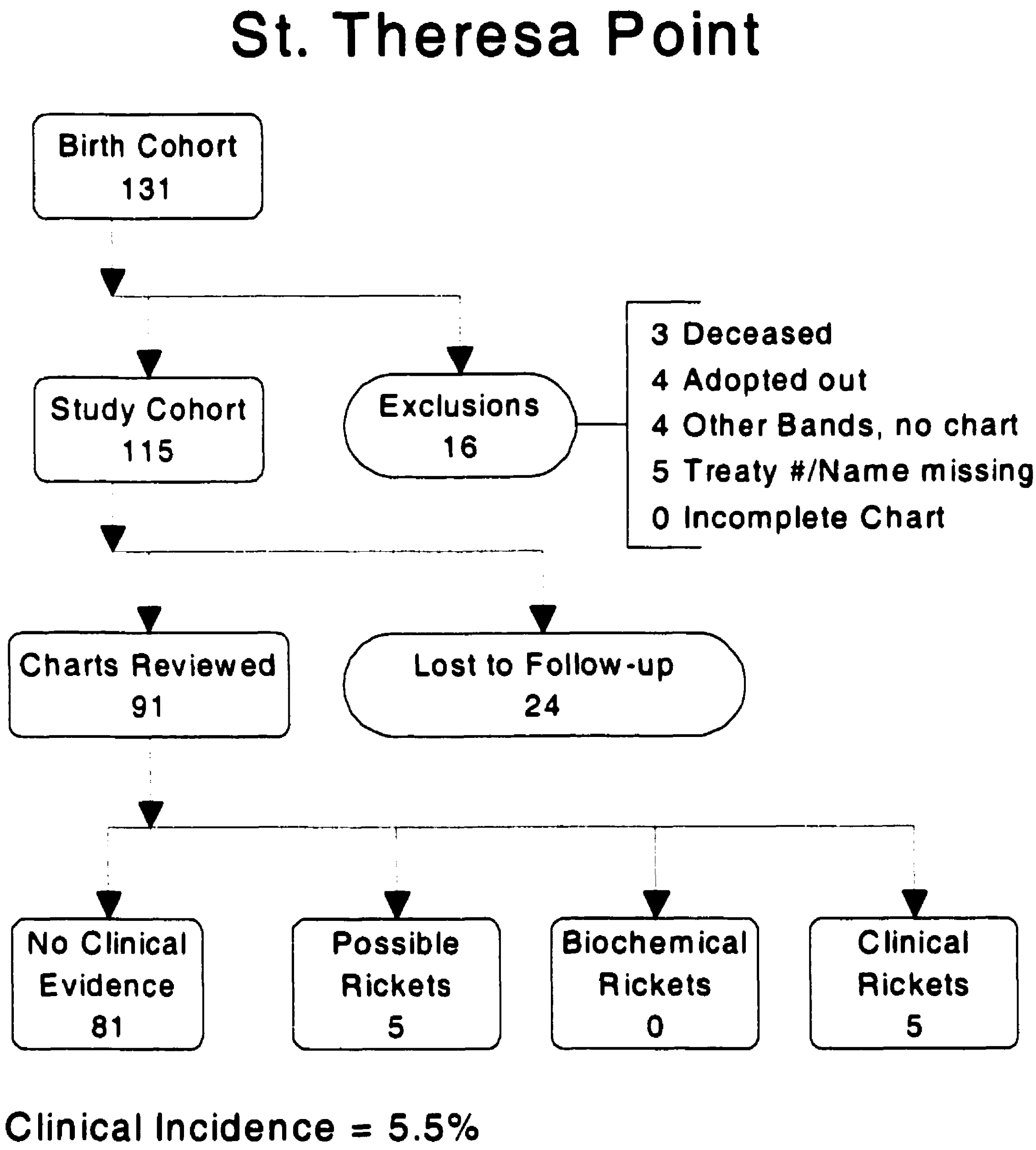

Figure 4: Results of the Medical Record Review in St. Theresa Point

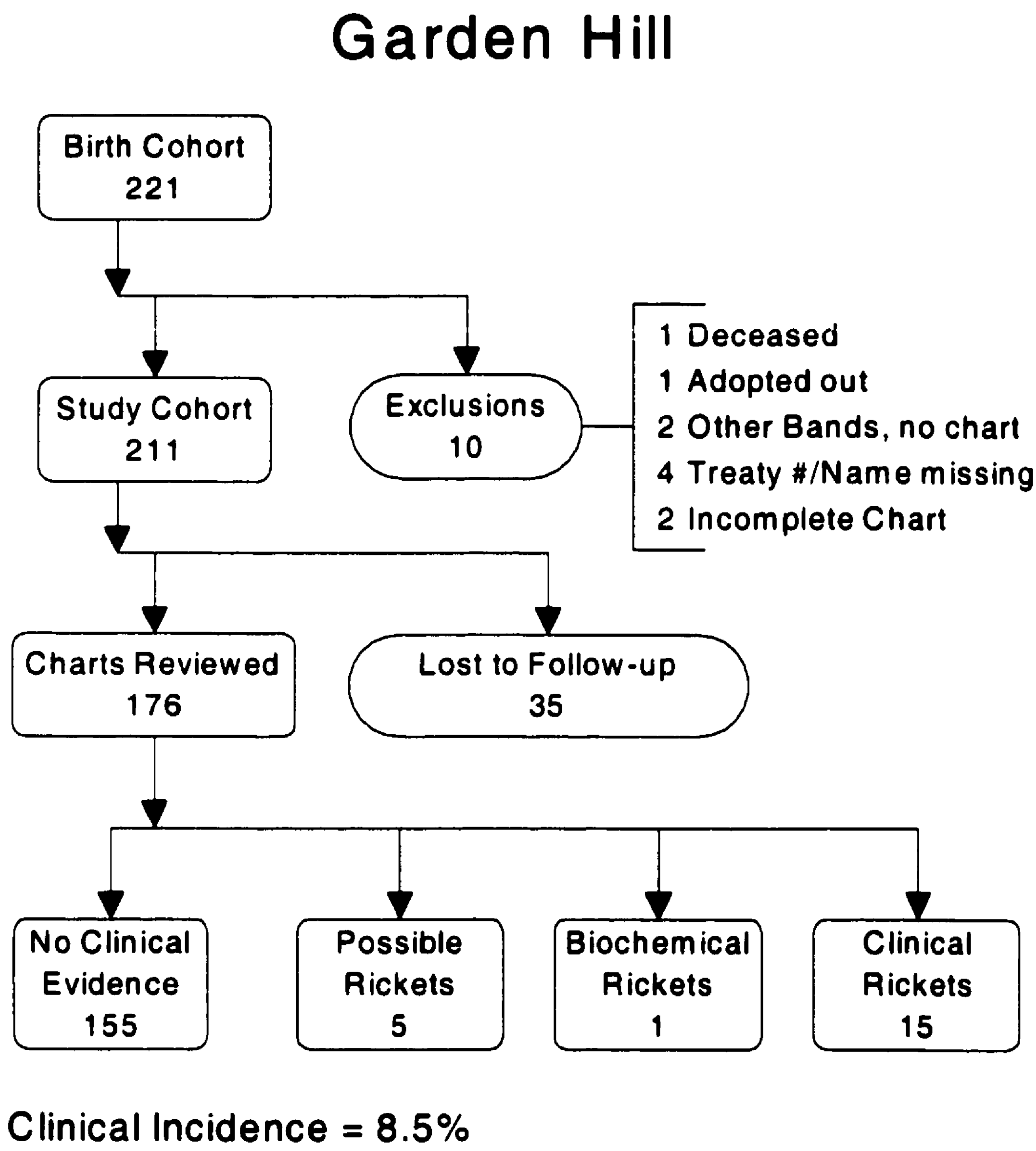

Figure 5: Results of the Medical Record Review in Garden Hill

Five children were identified in their charts, by nurses or doctors, as having rickets subsequent to presentation with clinical signs. Another 5 children had clinical signs but were never diagnosed with rickets. Caregivers were encouraged by nurses to give vitamins, and vitamin D supply was queried and encouraged. In St. Theresa Point, the rate of clinical rickets using the case definition (that includes a diagnosis of rickets or treatment for rickets following clinical signs) is 5 in 91 for the two-year period 1993 and 1994. According to clinical signs identified on the medical record review for this study, without the requirement of a diagnosis or treatment, the rate would be increased to 10 in 91.

In Garden Hill, there was evidence of 116 babies (60 female and 56 male) born in 1993 and 105 (50 female and 55 male) born in 1994. For 1993, the birth book contained 88 names, the fire evacuation list 21 and the band list a further 7 names. For 1994, the birth book contained 92 names and the band list a further 13. There was no fire evacuation list for 1994. The study cohort contained 87 children whose charts were reviewed for 1993 (with 7 cases of clinical rickets found), and 88 children whose charts were reviewed for 1994 (with 8 cases of clinical rickets found). There were also 5 possible cases. Several other children had a history of afebrile seizures that may be due to hypocalcemia but it is not possible to say if they had rickets. These cases did not meet the inclusion criteria. Two of the cases that originally presented with seizures and were later diagnosed with rickets had life-threatening seizures. For the two-year period, among the 176 charts in Garden Hill, 15 cases were found not including the child that "quit breathing" at 3 months and was diagnosed with rickets at 15 months on the basis of biochemistry with no prior clinical symptoms mentioned. Table 2 provides the clinical symptoms at presentation for all the rickets cases and possible cases from Garden Hill and St. Theresa Point.

The incidence of rickets in Garden Hill is not significantly different from that in St. Theresa Point, but the rate in Norway House is significantly different from the rate in Garden Hill ($P < 0.001$) and St. Theresa Point ($P < 0.005$).

Table 2: Clinical signs at presentation of rickets (cases and possible cases).

Sex	Symptoms	Age group (months)
Clinical Rickets:		
M	seizures, cardiorespiratory arrest	≤12
M	frontal bossing	≤12
F	bowed legs	≤12
F	bowed legs	≤12
M	bowed legs, enlarged wrists	≤12
F	bowed legs	≤12
M	bowed legs, rosary, flared epiphyses	13 to 24
M	flared wrists and ankles	13 to 24
M	bowed legs (4 months), sibling with rickets	13 to 24
M	bowed legs & arms, wrists swollen	13 to 24
F	seizures day 4, bowed legs	13 to 24
M	bowed legs	13 to 24
M	bowed legs	13 to 24
M	cardiorespiratory failure, clinical diagnosis in Winnipeg, anemia	13 to 24
M	bowed legs	13 to 24
F	bowed legs	13 to 24
F	bowed legs, pain	13 to 24
M	bowed legs	25 to 36
F	bowed legs, pain	25 to 36
F	bowed legs (18 months) diagnosed in Winnipeg	25 to 36
Biochemical Rickets:		
M	quit breathing 3 months, biochemical rickets, FTT*	13 to 24
Possible Rickets:		
M	anemia, high alkaline phosphatase, vitamin D recommended	≤12
M	anemia, high alkaline phosphatase, vitamin D prescribed	≤12
F	seizures "if no history of rickets, give phenobarb"	≤12
F	bowed leg, knee x-rays normal	13 to 24
M	seizures (4 months), high alkaline phosphatase, vitamin concern	13 to 24
F	quit breathing (9 months), FTT*, vitamin D recommended	25 to 36
F	bowed legs, not considered rickets, no tests	13 to 24
M	bowed legs but wrists normal, no tests, FTT*	13 to 24
M	bowed legs, wrist x-ray negative	≤12
M	bowed legs, high alkaline phosphatase, x-rays normal	13 to 24

*FTT = failure to thrive

7.2 Prevalence of vitamin D deficiency among pregnant women:

The first blood samples were collected October 17, 1997 in St. Theresa Point, October 21, 1997 in Garden Hill, and October 29, 1997 in Norway House. Blood collection was stopped in Norway House on June 25, 1998, in St. Theresa Point on July 6, 1998, and in Garden Hill at the end of the 12-month period on October 16, 1998. Table 3 shows the number of blood samples and interviews that were collected each month by community. A total of 115 blood samples were analyzed for 25-hydroxyvitamin D levels, calcium, phosphate, and alkaline phosphatase, 32 from Garden Hill, 35 from St. Theresa Point, 37 from Norway House, and 11 for whom no interviews were received and the community is unknown, as this information is not contained in the lab report. Three samples from Norway House women who were interviewed were never received at the lab in Winnipeg and the lab accidentally discarded one sample before the 25-hydroxyvitamin D level had been assessed.

Table 3: Blood samples and interviews by community by month (# bloods/# interviews)

Month	Garden Hill	St. Theresa Point	Norway House	Total
October	3 / 2	1 / 1	1 / 1	5 / 4
November	4 / 4	1 / 1	1 / 1	6 / 6
December	3 / 2	2 / 2	1 / 1	6 / 5
January	2 / 1	6 / 6	5 / 7	13 / 14
February	2 / 2	2 / 2	4 / 4	8 / 8
March	0 / 0	6 / 6	7 / 7	13 / 13
April	5 / 6	3 / 3	5 / 2	13 / 11
May	4 / 4	10 / 10	8 / 7	22 / 21
June	3 / 1	4 / 4	5 / 6	12 / 11
July	1 / 0	0 / 0	0 / 0	1 / 0
August	5 / 2	0 / 0	0 / 0	5 / 2
September	0 / 0	0 / 0	0 / 0	0 / 0
Total	**32 /24**	**35 / 35**	**37 / 36**	**104 / 95**

If the birth rate is assumed to be the same as in 1993 and 1994, the data collected for the medical record review and the number of months blood was collected in each community can be used to estimate the proportion of pregnant women from whom blood was analyzed. This estimation indicates that blood was analyzed for approximately 29.1% of the pregnant women from Garden Hill, 55.2% of the pregnant women from Norway House, and 76.1% of the pregnant women from St. Theresa Point.

For this study, vitamin D deficiency was defined as those cases with 25-hydroxyvitamin D levels below 35 nmol per litre as this is the lower limit of the normal range as provided by the laboratory (see Appendix 3). The laboratory tests cannot measure levels below 15 nmol/L, and this level was used as the threshold below which extreme deficiency exists. The overall prevalence of vitamin D deficiency among this sample of pregnant women from the three communities was 84.6% The overall prevalence of extreme deficiency is 17.3%. Demographic information and 25-hydroxyvitamin D levels are reported by community in Table 4.

The 25-hydoxyvitamin D measures were not normally distributed due to the high prevalence of deficiency and the truncation caused by the limitations of the laboratory test (see Figure 6). Figure 7 illustrates the distribution of the 25-hydroxyvitamin D levels, by community, using box plots. Because of the non-normal distribution, nonparametric measures were used to describe the distribution of values by community and to test for differences between the vitamin D status (deficient/not deficient) of the three communities. The Kruskal-Wallis test of the three communities was significant ($p=.047$), as was the Median test ($p=.026$). The Mann-Whitney *U* tests of pairs of communities indicated that a significant difference exists between Garden Hill and Norway House ($p=.020$), but not between Garden Hill and St. Theresa Point or between St. Theresa Point and Norway House. Vitamin D status by community is shown in Figure 8 (low and normal) and Figure 9 (very low, low and normal).

Table 4: Demographic information and 25-hydroxyvitamin D levels for study subjects.

	Garden Hill	St. Theresa Point	Norway House
25-hydroxyvitamin D levels[1] (n)	32	35	37
Median	18	21	24
Minimum	< 15	< 15	< 15
Maximum	59	63	60
Interquartile range	13.73	12.00	10.00
Questionnaires (n)	24	35	36
Age Mean	22.45	22.26	24.03
Median	21	22	23.5
Minimum	15	14	16
Maximum	32	30	35
# of children Mode	3	1 (0 and 2)	1
Range	0 to 7	0 to 5	0 to 5
# in household Mode	5	4	4.5 (3 and 6)
Range	2 to11	2 to 9	2 to 11
School Grade[2] Mode	8	10	12
Range	7 to 12	7 to Post-secondary	7 to Post-secondary
Family Income: Assistance[3]	16 (67%)	20 (57%)	13 (36%)
Part-time work	5 (21%)	6 (17%)	4 (11%)
Full-time work	1 (4%)	7 (20%)	15 (42%)
Sponsored training	0 (0%)	2 (6%)	4 (11%)
Unreported	2 (8%)	0 (0%)	0 (0%)

[1] The Mann-Whitney *U* tests of pairs of communities indicated that a significant difference exists between Garden Hill and Norway House ($P<0.020$).

[2] The Mann-Whitney *U* tests of pairs of communities found significant differences in education levels (highest grade level attained) between participants in Garden Hill and Norway House ($P<0.002$) and between Garden Hill and St. Theresa Point ($P<0.035$) and between St. Theresa Point and Norway House ($P<0.016$).

[3] The Mann-Whitney *U* tests of pairs of communities found significant differences in sources of income for participants in Garden Hill and Norway House ($P<0.001$) and between St. Theresa Point and Norway House ($P<0.035$).

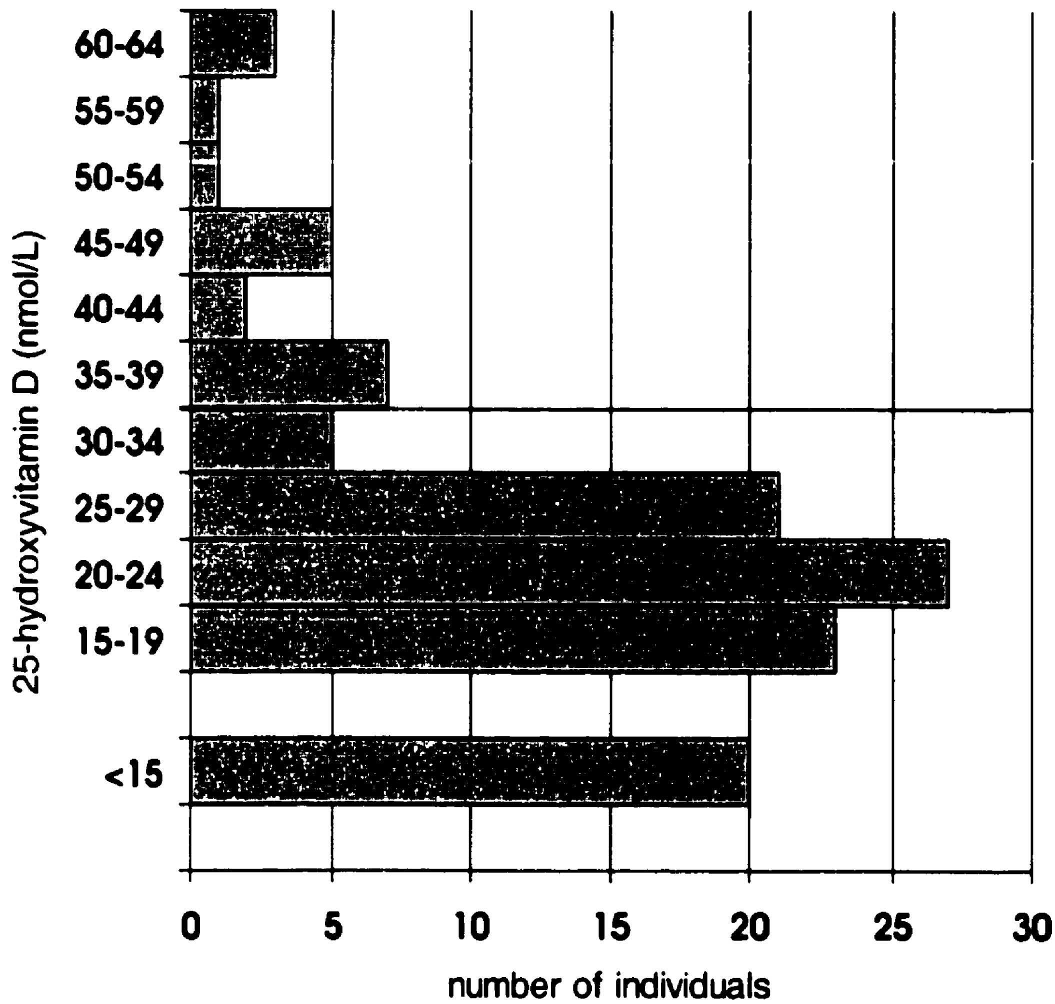

Figure 6: Serum 25-hydroxyvitamin D Levels: Total Sample (n=115)
*line at 35 nmol/L indicates lower limit of normal range

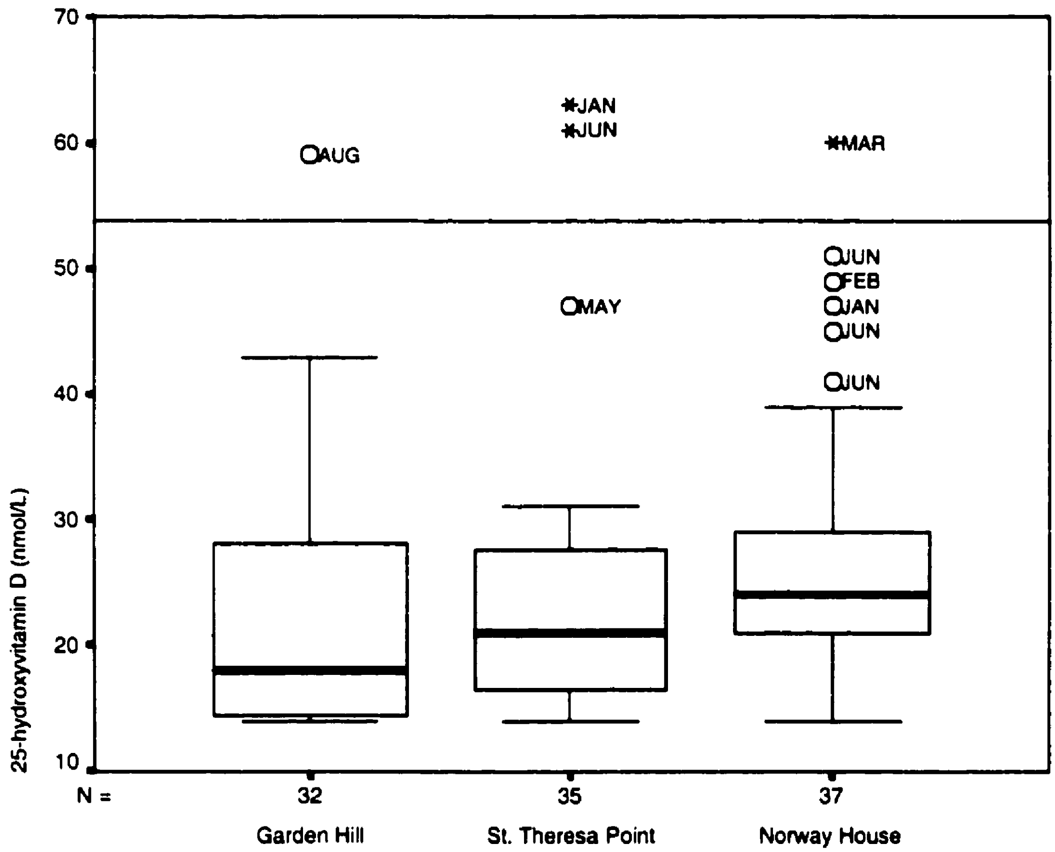

Figure 7: Serum 25-hydroxyvitamin D Levels: Distribution by Community (box plots).

The box represents the interquartile range (25^{th} and 75^{th} percentile); the whiskers represent the largest value that is not an outlier (more than 1.5 box-lengths from the 75^{th} percentile); the dark line represents the median; and the individual points are the outliers and extreme values (more than 3 box-lengths from the 75^{th} percentile) identified by month of blood collection. The line at 35 nmol/L represents the lower limit of the normal range.

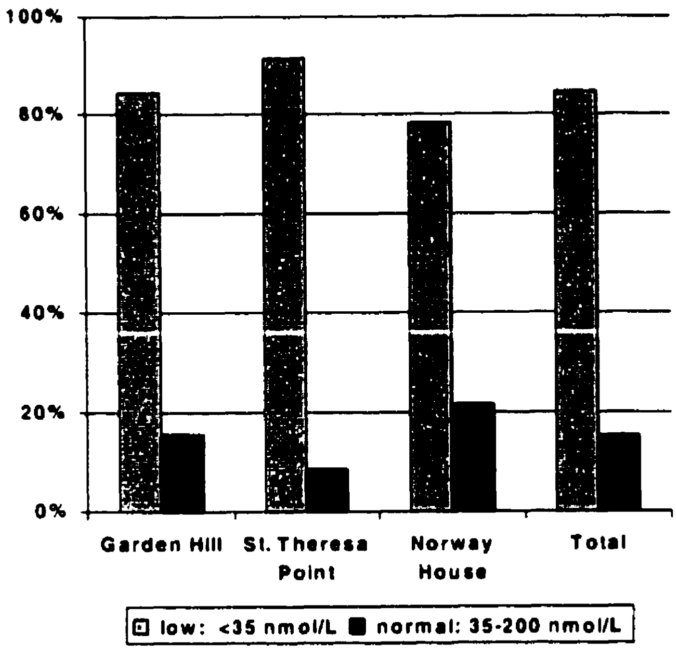

Figure 8: Vitamin D Status (low/normal) by Community

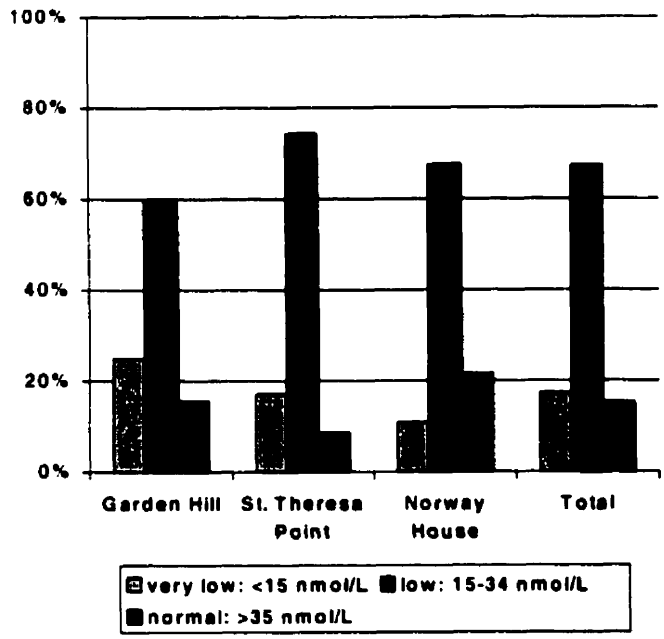

Figure 9: Vitamin D Status (very low/low/normal) by Community

Because 25-hydroxyvitamin D levels are affected by sun exposure, it was important to test the effect of season of blood collection on the 25-hydroxyvitamin D levels. The number of blood samples collected varied by month. Also, although all three communities began blood collection within two weeks of each other in October and two communities ended blood collection within two weeks of each other at the end of June, Garden Hill collected blood throughout the summer and into October. The Kruskal-Wallis test of 25-hydroxyvitamin D levels by season of blood collection did not indicate a significant association. None of the women had high-normal levels as none had a value over 63 nmol/L (normal range 35 to 200nmol/L). Table 5 reveals the number of women with and without vitamin D deficiency by season of blood collection.

Table 5: Vitamin D Status by season of blood collection (count)

	Fall (Oct-Dec)	Winter (Jan-Mar)	Spring (Apr-Jun)	Summer (Jul-Sep)	Total
Normal *	0	4	11	4	19
Low **	17	31	44	4	96
Total	17	35	55	8	115

*Normal Vitamin D Status: 25-hydroxyvitamin D levels ≥35nmol/L
**Low Vitamin D Status: 25-hydroxyvitamin D levels <35nmol/L

The normal values for serum calcium ranged from 2.10 to 1.69 mmol/L for all the women. The normal values for serum phosphate and alkaline phosphatase depended on whether or not the woman was over sixteen years of age. For women over age

16, the normal range for phosphate was 0.81 to 1.45 mmol/L and alkaline phosphatase was 30 to 120 U/L, compared to 1.29 to 2.26 mmol/L and 59 to 422 U/L respectively for those age 16 and under. Only nine of the pregnant women were 16 years and under: 5 were 16; 1 was 15; and 3 were 14. Seven of these women had phosphate levels that were low, although they would have been considered normal if the adult range had been used. One woman had a very high level (4.32 mmol/L) for either age group. For alkaline phosphatase, two of the values in the normal range for children would have been considered high if the adult range had been used. The serum values were retained as continuous variables in the statistical analysis of their association with 25-hydroxyvitamin D levels. None of the other serum measures explained a significant amount of the variation in 25-hydroxyvitamin D values. Serum 25-hydroxyvitamin D, alkaline phosphatase, calcium, and phosphate status results are presented in Appendix 8 by community.

7.3 Risk factors:

Ninety-five face-to-face interviews were conducted to collect contextual data important for understanding causation and prevention. Upon recruitment into the study and after collection of blood samples, the women were interviewed by the local research assistant. Interviews were received from 24 from Garden Hill, 35 from St. Theresa Point, and 36 women from Norway House. A further seven interviews from Garden Hill were never received and may have been lost in the mail. These were the last interviews conducted before the end of the study period. Significant differences were found between specific variables related to sun exposure and other questionnaire variables between the two communities (Garden Hill and Norway House) with significantly different vitamin D status (see Table 6). Pearson chi-square tests were used to compare the frequency of people who responded with low versus high exposure to risk factors for vitamin D deficiency. Questions with multiple responses of an ordinal nature that had a small number of responses in some categories were combined to give the binary breakdown that gave each category a proportion closest to 50%. For example, for sunscreen use, the comparison was never and rarely responses versus sometimes, often and always responses, but for the wearing shorts or skirts, the comparison was between never, rarely, and sometimes responses and often plus always responses. Appendix 9 provides a summary of the frequency counts for the responses to each closed-ended question by community. The percentage of women within each community who provided each response is also included in Appendix 9 because of the difficulty making comparisons with count data due to the unequal number of respondents in each community.

Table 6: Variables that differ significantly between Norway House and Garden Hill. Directionality is indicated with bold font for Garden Hill respondents. (All tests were chi-square tests except for the Mann-Whitney *U* test of calcium foods index).

VARIABLE	COMPARISON	n	*P* <
Sunscreen use	**Never/rarely** vs. sometimes/often/always	58	.003
Wear shorts/skirts	**Never/rarely/sometimes** vs. often/always	60	.002
Time in summer sun	**< 1 hour** vs. ≥ 1 hour	60	.034
Feel vitamins necessary	Yes vs. no vs. **don't know**	60	.000
Think vitamins not natural	Yes vs. no vs. **don't know**	60	.002
Use whitener in tea/coffee	Never vs. sometimes vs. **often**	59	.000
Eat yogurt	**Never** vs. sometimes vs. often	60	.049
Eat broccoli	**Never** vs. sometimes vs. often	59	.004
Eat other green vegetables	**Never** vs. sometimes vs. often	60	.002
Eat turnip	**Never** vs. sometimes vs. often	58	.007
Eat meat soup (from bones)	**Never** vs. sometimes vs. often	60	.000
Eat pasta/bread most days	Yes vs. **no**	59	.000
Eat vegetables most days	Yes vs. **no**	57	.000
Eat fruit most days	Yes vs. **no**	60	.000
Eat meat most days	Yes vs. **no**	59	.000
Calcium foods index	**lower** in Garden Hill	60	.001
Someone in family gardens	Yes vs. **no**	57	.015
Evaporated milk to baby	Yes vs. **no**	38	.046
Whole milk to baby	Yes vs. **no**	37	.000
Age baby began milk/formula	< 3 months vs. **≥3 months**	43	.002
Frequency: vitamins to baby	**Never/rarely/often** vs. most days/daily	59	.026
Sick after milk	Yes vs. **no**	60	.015
Have bone pain	Yes vs. **no**	58	.006

The calcium index was created by adding the ordinal value of all responses to the questions asking about consumption of calcium-containing foods, with no weighting for the relative importance of the sources of calcium. The Mann-Whitney *U* test was used to find a significant difference in this index of calcium-containing foods between Garden Hill and St. Theresa Point. For the variables that were significantly different the values associated with increased risk for vitamin D deficiency were more prevalent in Garden Hill except for use of sunscreen, feeling sick after drinking milk, and having bone pain.

7.4 Prevention:

Potential strategies for prevention of vitamin D deficiency were proposed based primarily on the results of the interview data. Many of the interview questions were open-ended and addressed the changeability of potential risk factors for vitamin D deficiency.

Table 7 summarizes the responses to the question "How do you feel about spending time in the sun in summer?" Half of the women from Garden Hill, 32% from St. Theresa Point and 39% from Norway House spoke negatively about spending time in the sun. These negative comments mostly reported that it was "too hot" but one St. Theresa Point woman said that "too much sun is bad for you" and a Norway House resident reported that she gets "worried about UV rays." Seventy percent (66 of 94) of the women indicated that they would be willing, when asked "If you thought that being in the sun more would be good for your health, would you try to spend more time in the sun?" Twenty percent did not know if they would be willing to spend more time in the sun, and 10% (4 women from St. Theresa Point and 5 from Norway House) said they would not be willing to spend more time in the sun.

Table 7: Summary of responses to: "How do you feel about spending time in the sun in summer?"

	Garden Hill		St. Theresa Point		Norway House		Total	
	#	%	#	%	#	%	#	%
Negative feelings	11	46	11	31	14	39	36	38
Positive feelings	11	46	23	66	22	61	56	59
Don't know	2	8	1	3	0	0	3	3
Total	24	100	35	100	36	100	95	100

Near the end of the interview, after having been asked what the women would do if they learned they were vitamin D deficient, they were asked "Which of the following changes they would be willing to make?" The fourth suggestion in the list was "spend more time in the sun" and the results were very similar to the earlier question that mentioned their health but not a personal deficiency. The majority of women (70.5%; 67 of 95) indicated that they would be willing to spend more time in the sun. Nineteen percent did not know if they would be willing; and 10.5% (2 from Garden Hill, 3 from St. Theresa Point and 5 from Norway House) said they would not be willing to spend more time in the sun.

When asked how they felt about vitamin pills, 68% of the pregnant women provided positive responses such as "I don't mind them" and " They are good because they help to keep you healthy"(see Table 8). Twelve percent (7 from St. Theresa Point and 4 from Norway House) gave negative responses including "...they make me sick," "I don't like the smell and the aftertaste," and "...I am not all that keen on taking pills or medicine." One woman from Norway House said "I guess they're okay. They make me eat a lot."

Table 8: Summary of responses to: "How do you feel about vitamin pills?"

	Garden Hill		St. Theresa Point		Norway House		Total	
	#	%	#	%	#	%	#	%
Negative feelings	0	0	7	20	4	11	11	12
Positive feelings	12	52	21	60	31	86	64	68
Don't know	11	48	7	20	1	3	19	20
Total	23	100	35	100	36	100	94	100

Forty-eight of the 88 responses to the question "What do you think vitamins do when you take them?" indicated an understanding of the role of vitamins in the health of the mother, baby or both. One person from Norway House expressed the view that vitamins "keep you healthy when you don't eat the right foods", and two (one from St. Theresa Point and one from Norway House) said that vitamins "help you grow" or "help the baby grow." Four women indicated that vitamins increase your appetite. Two women from Norway House felt that vitamin pills make you "eat more" and "gain weight," and one said "They help me with my appetite and help me to keep healthy." One St. Theresa Point woman felt that vitamin pills made her "crave for food." Almost half (48%) of the women from Garden Hill answered with "I don't know," as did 41% from St. Theresa Point, but only 11% from Norway House.

When asked for the reasons for their vitamin use frequency (most days/often/rarely/only when pregnant/never), the majority said they took vitamins either because they were told to (25 of 79) or because they would be good for their own and their baby's health (21 of 79). Fifty-three of 94 women (56%) reported that they only took vitamins when pregnant. Five women from St. Theresa Point said that they only took vitamins during pregnancy because that was the only time they get them, and one woman from Norway House said she felt that, other than during pregnancy, she does not need vitamins. Thirty percent of women reported that they never (n=14) or rarely (n=14) took vitamins. One Norway House woman whose 25-hydroxyvitamin D level was in the normal range and who reported that she rarely takes vitamins, said she takes them "sometimes when I feel I haven't had vitamins or milk."

Of those women who do not take vitamins: five keep forgetting to take them and one forgets to buy them; two feel they have never needed them; one is waiting for the results of a blood test to find out if she needs them; two don't like taking pills; and one reports that vitamins make her sick. One woman, whose 25-hydroxyvitamin D level was low and who worries about UV rays, said she does not take vitamins because "I try to get them from the foods I eat."

When asked why they did or did not take vitamins after being encouraged to do so by health professionals, most women reported that they took them because they thought they had been given good advice, though several reported difficulty remembering to take vitamins. Of those women who did not take vitamins: two from St. Theresa Point reported that vitamins were not available; one from Norway House reported having been told not to take any pills; and two from Norway House (both of whom had low 25-hydroxyvitamin D levels) felt that it was not necessary to take vitamins. One Norway House woman responded that "When the doctor gave [it to] me, it was through a shot (needle)." Another Norway House woman reported that vitamins had not been prescribed for her and still another reported that she had just been given a prescription and would take them. The following response from a woman from St. Theresa Point explains why she does not take vitamins: "I was told by my mother that my baby will be overweight when born."

Table 9 summarizes the responses to the question: How would you feel about taking a large dose of vitamin D once a year? Some women that said they would take it qualified their response with comments such as "if I needed to," "if I knew I was low," and "if it was safe." The reasons for agreeing to take a high dose vitamin D supplement included "if it would help to prevent abnormalities," "it would help my health" and " it would be better than having to remember to take one every day." Three women from St. Theresa Point said that they would feel "uncomfortable" with a high dose, and one woman from Norway House said that she would be "scared" but she thought it would help her. Another woman from Norway House felt that she did not need an annual high dose because she takes vitamins regularly. Unfortunately the laboratory did not receive blood from this individual so we cannot tell if her 25-hydroxyvitamin D level was in the normal range. Table 10 gives the reported willingness of the women to take a large dose of vitamin D once a year. Twelve percent said they would not.

Table 9: Summary of responses to: "How would you feel about taking a large dose of vitamin D once a year?"

	Garden Hill		St. Theresa Point		Norway House		Total	
	#	%	#	%	#	%	#	%
Negative feelings	0	0	3	9	2	6	5	6
Positive feelings	7	32	13	38	29	80	49	53
Don't know	15	68	18	53	5	14	38	41
Total	22	100	34	100	36	100	92	100

Table 10: Reported willingness to take a large dose once a year.

	Garden Hill		St. Theresa Point		Norway House		Total	
	#	%	#	%	#	%	#	%
No	1	4	8	23	2	6	11	12
Yes	5	22	17	48	29	83	51	55
Don't Know	17	74	10	29	4	11	31	33
Total	23	100	35	100	35	100	93	100

Near the end of the interview, the women were asked "Which of the following changes would you be willing to make?" if they learned they were vitamin D-deficient. Eighty-eight percent of the women (84 of 94) reported that they would take vitamins regularly (the rest said they did not know), and 70% (66 of 94) said they would take a high dose vitamin supplement once a year (26% said they did not know, and 4% said no).

The question "How have you changed your diet since you learned you were pregnant?" elicited responses that fell into 4 categories: not at all; ate less than normal because of nausea; ate more than normal; and ate better than normal; as well as several who said yes but did not elaborate on how their diet had changed. Ten women were trying to eat more healthily and two said that they always eat a healthy diet. The food groups mentioned by those trying to improve their diet are fruits, vegetables, and dairy products. Those are the foods women report trying to eat more of, while some report eating less junk food and greasy/fried food.

All of the 59 women who provided the names of foods that they thought provided the main sources of calcium in their diet included appropriate foods, although some included unlikely sources as well. Milk and cheese/dairy products were most frequently mentioned, (51 and 39 times, respectively). Yogurt (15 times) and ice cream (9) were the next most common foods given. The four people who reported fish as a main source of calcium did not mention milk, although two reported cheese. Other suggestions included milkshakes, fruit drinks, fruits and vegetables, eggs, meats, and "all four food groups." Eleven women said that they did not know what the main sources of calcium were in their diet.

Table 11 summarizes the responses to the question "How do you feel about milk?" The only "don't know" responses came from Garden Hill (n=6). If all of the "don't know" responses are assumed to be negative, 35% of the women from Garden Hill, 23% from St. Theresa Point, and 28% from Norway House, do not have positive feelings about milk. One woman from Norway House, whose 25-hydroxyvitamin D level is below normal, reports "I know it is good for me and baby but I rarely drink it." Another Norway House resident, whose 25-hydroxyvitamin D level is in the normal range (although low-normal) says "I like milk, two glasses before and now four glasses since I became pregnant." When asked if they think milk is good for adults, none of the women said no, although several did not know (see Table 12).

Table 11: Summary of responses to: "How do you feel about milk?"

	Garden Hill		St. Theresa Point		Norway House		Total	
	#	%	#	%	#	%	#	%
Negative feelings	2	9	8	23	10	28	20	21
Positive feelings	15	65	27	77	26	72	68	72
Don't know	6	26	0	0	0	0	6	7
Total	23	100	35	100	36	100	94	100

Table 12: Responses to: "Do you think milk is good for adults?"

	Garden Hill		St. Theresa Point		Norway House		Total	
	#	%	#	%	#	%	#	%
No	0	0	0	0	0	0	0	0
Yes	15	65	32	91	35	97	82	87
Don't Know	8	35	3	9	1	3	12	13
Total	23	100	35	100	36	100	94	100

When the women were asked why they do not eat more of foods that they indicated they would like to eat more of, most of the responses indicated that money and availability were the main reasons. Thirteen women from Garden Hill, 16 from St. Theresa Point, and 2 from Norway House specifically mentioned the high cost of those foods or their own lack of money. Availability problems were cited by 11 women from St. Theresa Point and 2 from Norway House, but none from Garden Hill. Other reasons included the lack of a refrigerator to store perishables, the need to make trips to the store more frequently, and the lack of family members who fish or hunt. When asked if they would eat more of these foods if they were less expensive, 75 of 93 said they would, 11 did not know, and 7 said no.

Fifty-eight women responded to the question "What did you think of this advice?" referring to having been encouraged by health professionals to drink milk. All but 6 (2 who never thought about it and 4 who did not know what they thought of it) indicated that they thought it was good advice. When women were asked why they did or did not drink more milk following this advice: 26 drank more or tried to drink more; 12 felt they drank lots of milk anyway; 3 said it made them sick; 8 said they do not like milk; and 6 said milk was too expensive. One woman explained why she did not drink more milk this way: "Because I'm hardly home, plus I like to drink water."

The open-ended question "How would you feel about having vitamin D or calcium put in a food you eat, and you couldn't tell it was there, except for the package label?" did not elicit any completely negative responses. The most negative was this: "I don't think I would eat it if it was on a package. I'd rather not know." A few women commented that they do not read labels and so, in the words of one woman, "wouldn't know anyways." Most women would not mind having food fortified. One woman said "it's good if it is the only way to get vitamins." Table 13 gives the results of the questions: "Would you continue to eat this food if you eat it now?"; and "Would you try to eat more of that food if you didn't normally eat much of it?"

Table 13: Responses to questions about food fortified with vitamin D or calcium

		Garden Hill		St. Theresa Point		Norway House		Total	
		#	%	#	%	#	%	#	%
Would you still eat this food?	No	0	0	0	0	0	0	0	0
	Yes	17	71	32	91	35	97	84	88
	Don't know	7	29	3	9	1	3	11	12
	Total	24	100	35	100	36	100	95	100
Would you try to eat more of it?	No	2	8	6	17	1	3	9	9
	Yes	12	50	19	54	29	83	60	64
	Don't know	10	42	10	29	5	14	25	27
	Total	24	100	35	100	36	100	94	100

The potential to add powdered milk to foods that women are already preparing was pursued. Although several women specifically report that they do not like (n=2) or use (n=5) powdered milk, forty-seven women offered ideas. Bread, bannock, cakes, mashed potatoes, soups, sauces, gravies, puddings, pasta, yogurt, cereals, scrambled eggs, creamed vegetables and coffee were suggested as foods that could have powdered milk added to them.

The question "What foods are especially good for pregnant women?" elicited a range of answers. Seventeen women mentioned wild foods (14 from St. Theresa Point, 2 from Garden Hill, and 1 from Norway House). Twelve women mentioned the "four food groups" (11 from Norway House, 1 from St. Theresa Point, and none from Garden Hill). Boiled food was suggested by two women from Norway House, and meat, vegetables, fruit and milk were common suggestions.

After having been asked what they would do if they learned they were deficient, the women were asked if they would be willing to: eat more dairy products; support efforts to have vitamin D and calcium added to common foods; support efforts to make dairy products more affordable; and try to find non-dairy, diet sources of vitamin D and calcium. The results of these questions, along the other questions from this list (mentioned earlier) are presented in Table 14.

Table 14: Responses to: "If you found out that you were vitamin D-deficient... which of the following changes would you be willing to make?"

	Yes		No		Don't know		Total (n)	
	#	%	#	%	#	%	#	%
Eat more dairy products	85	89	4	4	6	6	95	100
Take vitamins regularly	84	89	0	0	10	11	94	100
Take a high dose vitamin supplement annually	66	70	4	4	24	26	94	100
Spend more time in the sun	67	71	10	11	18	19	95	100
Support efforts fortify foods with vitamin D and calcium	77	81	1	1	17	18	95	100
Support efforts to make dairy products more affordable	86	91	1	1	8	87	95	100
Try to find non-dairy vitamin D/calcium sources	75	80	4	4	15	16	94	100

The pregnant women who already have children were asked whether or not they had given vitamins to their last baby, and then were asked why or why not. Most women said that they gave their baby vitamins because they were instructed to do so or because they wanted their babies to be healthy. Those women who did not give vitamins said they forgot or did not think they needed them. A Norway House woman said "because I feed my baby with good foods." A 21 year-old Norway House mother reported that she "didn't have it and know about it." One Garden Hill woman said that she gave vitamins because of "reading pamphlets."

When asked "If you found out that you were vitamin D-deficient, what would you do?" the answers feel into several categories, although these are not very different from one another (see Table 15). A Garden Hill woman with several children and low serum 25-hydroxyvitamin D said that she would like to read about it. A Norway House woman reported that she would like to "heal myself."

The last questions of the interview asked to see the supplies of milk, cheese and vitamins in the house. Although the interviews were supposed to take place in the home of the woman, not all interviews were conducted there, some by the choice of the woman and some by the choice of the interviewer. Although the location of the interview is mentioned on some forms, it is not always possible to tell if the interviewer saw these items or was recording what she was told. However, most entries were detailed enough to indicate that the items were seen (e.g. 2L 2% milk, 2L Homo, 2 cans Pacific). The results of these questions are presented by community and by vitamin D status in Table 16.

Table 15: Summary of responses to: "If you found out that you were vitamin D-deficient, what would you do?"

	Garden Hill		St. Theresa Point		Norway House		Total	
	#	%	#	%	#	%	#	%
Eat better	0	0	2	6	9	30	11	14
Take vitamins	0	0	5	16	12	40	17	22
Seek help	3	16	15	49	2	7	20	25
Eat better/vitamins & sun	0	0	2	6	0	0	2	2
Eat better & seek help	0	0	3	10	3	10	6	8
Read/heal self	1	5	0	0	1	3	2	2
Eat better & vitamins	0	0	0	0	2	7	2	2
Don't know	15	79	4	13	1	3	20	25
Total	19	100	31	100	30	100	80	100

Of the women interviewed from Garden Hill for whom an answer was provided, only 11 of 23 had milk, 6 of 23 had cheese, and 3 of 23 had vitamins in the house at the time of the interview. In St. Theresa Point, 25 of 35 women had milk, 15 of 34 had cheese, and 22 of 31 had vitamins. In Norway House, 35 of 35 women had milk, 35 of 35 had cheese and 20 of 31 had vitamins. All six of the women who included coffee whitener in the list of milk products were from Garden Hill. One woman from Garden Hill that did not have vitamins in her home did have iron pills, and two of the 21 women from St. Theresa Point that did have vitamins had only children's vitamins.

Table 16: Supply of milk, cheese and vitamins by vitamin D status and community.

	Normal Vitamin D Status								Low Vitamin D Status							
	Garden Hill		St. Theresa Point		Norway House		Total		Garden Hill		St. Theresa Point		Norway House		Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Milk																
No answer	3	60	0	0	0	0	3	19	6	22	0	0	2	7	8	9
No/none	1	20	2	67	0	0	3	19	11	41	8	25	0	0	19	22
Yes	1	20	1	33	8	100	10	62	10	37	24	75	27	93	61	69
Total	5	100	3	100	8	100	16	100	27	100	32	100	29	100	88	100
Cheese																
No answer	3	60	0	0	0	0	3	19	6	22	1	3	2	7	9	10
No/none	1	20	2	67	0	0	3	19	16	59	17	53	0	0	33	38
Yes	1	20	1	33	8	100	10	62	5	19	14	44	27	93	46	52
Total	5	100	3	100	8	100	16	100	27	100	32	100	29	100	88	100
Vitamins																
No answer	3	60	1	33	0	0	4	25	6	22	3	9	6	21	15	17
No/none	2	40	1	33	5	63	8	50	18	67	8	25	6	21	32	36
Yes	0	0	1	33	3	38	4	25	3	11	21	66	17	58	41	47
Total	5	100	3	99	8	100	16	100	27	100	32	100	29	100	88	100

7.5 Participatory approach:

The study included elements of participation in this researcher-instigated study. All of the community leaders and members were supportive of the proposed research. Despite this support, the participatory elements had only limited success. Rickets was not an issue of high priority for the Island Lake communities. Although many people would have known children with bowed legs who were diagnosed with rickets, there are usually no apparent permanent sequellae. The visible bony effects of rickets among young children tend to be self-correcting with time, attributed to changes in age-related growth rates, sun exposure and diet following infancy. Thus rickets may have been viewed as just another minor childhood illness, and one that manifests with less urgency and disruption than fevers and earaches. The nursing station staff in Garden Hill were very busy and there were high rates of staff turnover. The planned Rickets Committee included only three regular members and it was difficult to get even those three people to meet together on the occasions that I was in the community. The three Garden Hill residents most involved in this study included a volunteer, a Community Health Representative, and the research assistant for this study. They were involved in key informant interviews and questionnaire preparation. They will be presented with the study results and all recommendations will be developed with their input. Although true participatory research begins and ends in the communities, and is difficult (if not impossible by definition) to operationalize from outside the community, even the limited participation that occurred during this study was valuable.

8. DISCUSSION

The incidence of clinical rickets in the study communities confirms the longstanding clinical knowledge that rickets is a problem in the Island Lake area but is not a problem in Norway House. Thus the first hypothesis was correct. The rates calculated for St. Theresa Point and Garden Hill are likely to be underestimates, and, due to the self-correcting nature of most cases of rickets, it is possible that some cases were missed in Norway House where cases were not expected. The widespread subclinical vitamin D deficiency of the pregnant women in all three communities suggests that many children could have rickets but are never diagnosed. As no deficiency was expected in Norway House prior to this study, confirmation of the high prevalence predicted is an important finding of this study. The prevalence of vitamin D deficiency in Norway House was even higher than predicted in this study (78% versus 55%).

Although vitamin D deficiency of a widespread nature was demonstrated among the participants of this study in all three communities, the ability to generalize to the population of pregnant women in these communities is limited by the low estimated proportions of pregnant women recruited to the study (29% from Garden Hill, 55% from Norway House, and 76% from St. Theresa Point). Some women were not included in the study in Garden Hill and St. Theresa Point because they were given high-dose vitamin D supplements before their blood was drawn. The research assistants in each community had knowledge of many of the pregnancies and reported that the pregnant women least likely to take part in the study were the younger ones. The Mann-Whitney *U* test found that younger women (20 years and under) did not have 25-hydroxyvitamin D levels that were significantly different from the older women. Also, despite the different estimated recruitment rates from Garden Hill and St. Theresa Point (29% versus 76%), the 25-hydroxyvitamin D levels and demographic variables did not differ significantly between the participants from the two communities except for education level. The modal value for highest grade attained was grade 8 in Garden Hill and grade 10 in St. Theresa Point.

It may be that the women who did not take part in the study were better nourished than those who did participate, but it seems more likely that the most health conscious women agreed to take part. Certainly, the women who did participate expressed concern for their own and their children's health and a willingness to seek professional help and heed the advice of health professionals. Their intentions and their actions did not always coincide, but many women provided reasons for not increasing milk and vitamin consumption that were reasonable in their circumstances.

Because of the lack of visible indications of vitamin D deficiency (rickets and osteomalacia) in Norway House, the finding that vitamin D deficiency is common among pregnant women was contrary to the expectations of the health professionals working in that community. Norway House was selected as a comparison community because it did not have a rickets problem. The scientific literature from several disciplines led to the hypothesis that vitamin D deficiency would be common in Norway House but that the extent and magnitude would be less than in the Island Lake area where rickets is a problem. The discovery that 78% of the sample was deficient indicates that a hitherto unrecognized problem exists. It also means that some of the planned multivariate statistical analyses were not informative. The lack of variation in the outcome (84.6% vitamin D deficiency) means that a model that simply predicts that every woman is deficient is correct 84.6% of the time. Adding any explanatory variables to a logistic regression model quickly leads to 100% predictive ability and the warning that the solution is not unique. The lack of association of 25-hydroxyvitamin D levels with the season of blood collection is likely due to inadequate statistical power resulting from small numbers and the extent and magnitude of the vitamin D deficiency of the sample.

Despite the similar non-normal distributions (with large numbers of low values and a long right tail), and similar ranges of values (from too low to measure to approximately 60 nmol/L), a significant difference was found between Garden Hill and Norway House, with a higher median value in Norway House. The median value for St. Theresa Point was intermediate between those for the other two communities but the differences were not significant. The sample size was not adequate to detect significant differences between St. Theresa Point and Norway House because the prevalence in Norway House was higher than estimated in *a priori* sample size calculations. Despite high prevalence of vitamin D deficiency in all three communities, the results support confirmation of the second hypothesis that vitamin D deficiency is of a greater extent and magnitude in Island Lake than Norway House. The current clinical relevance of this difference is exhibited in large numbers of rickets cases in Island Lake and not in Norway House. If subclinical vitamin D deficiency is important for other reasons, the difference in magnitude between the communities becomes less important than the fact that the majority of all the pregnant women had hypovitaminosis D.

Risk factors for vitamin D deficiency were common in all the communities, as expected given the high prevalence of deficiency in all three communities. Because of this overall high prevalence of vitamin D deficiency, logistic regression modeling was not meaningful. Risk factor data from Garden Hill and Norway House, the two communities that had significantly different 25-hydroxyvitamin D levels, were compared using univariate statistical tests. Significant differences were found for specific variables associated with risk for vitamin D deficiency and rickets (sun exposure, vitamins, and consumption of calcium containing foods).

Residence in Garden Hill was associated with: less sun exposure; less knowledge about vitamins; more use of coffee whitener; less consumption of yogurt, broccoli, other green vegetables, turnip, and meat soup; reduced likelihood of consuming pasta, meat, fruit and vegetables most days; reduced likelihood of having a family member who gardens; less provision of vitamins and evaporated or whole milk to babies, as well as later age for starting babies on milk or formula.

Sunscreen use was more common in Norway House and might be expected to impede the synthesis of vitamin D by blocking the required sun's rays. However, the use of sunscreen may be a marker for higher income and higher education, especially with respect to health promotion. Garden Hill residents were also less likely than Norway House residents to feel sick after drinking milk (2/24 versus 13/36). This suggests that lactose intolerance may be more prevalent in Norway House and would be unlikely to explain why Garden Hill has rickets when Norway House does not. Fewer pregnant women from Garden Hill than Norway House reported bone pain (1/22 versus 13/36 respectively). This question attempted to identify the prevalence of a potential indicator of osteomalacia, but bone pain is not specific to any one condition and the question is open to various interpretations. As an indicator of osteomalacia, greater prevalence would have been expected in Garden Hill, the community with the greater deficiency.

The third hypothesis was also confirmed. Several risk factors for vitamin D deficiency were significantly more prevalent in Garden Hill than in Norway House. This is consistent with the finding of more prevalent and more profound deficiency in Garden Hill (as evidenced by a greater proportion of women with values below normal, a lower median value, and a greater proportion of women with values too low to be measured). Still, although the factors known to be protective against vitamin D deficiency were more common in Norway House, the majority of women from Norway House were vitamin D-deficient.

Of the women interviewed from Garden Hill for whom an answer was provided, only 11 of 23 had milk, 6 of 23 had cheese, and 3 of 23 had vitamins in the house at the time of the interview. In St. Theresa Point, 25 of 35 women had milk, 15 of 34 had cheese, and 22 of 31 had vitamins. In Norway House, 35 of 35 women had milk, 35 of 35 had cheese and 20 of 31 had vitamins. The differences coincide with the magnitude of the deficiency problem. It should be noted that widespread deficiency exists in Norway House despite this indication that these products are a usual part of the household. Because more of the Norway House than St. Theresa Point interviews took place outside the home, reports of supplies were not always validated by the interviewer. However, the self-reported consumption data supports the likelihood that more homes in Norway House have regular supplies of these items.

This study collected information on beliefs and practices and asked women for their feelings about the sun, milk, vitamins, and other factors related to beliefs and practices pertinent to vitamin D status. These social and cultural factors were included in order to aid in understanding the broader context of vitamin D deficiency. The insight gained from this study will be valuable in helping move from the present focus on treatment to a focus on prevention.

A number of avenues exist for prevention strategies that are based upon research such as this that considers the social context of this disease. Improvements in the socioeconomic status of most North Americans have been responsible for tremendous improvements in health as a result of improved living conditions, including diet, sanitation, and better housing. Improvements in socioeconomic status are direly needed for Aboriginal people and any successful attempts to do so would have wide-ranging benefits. That anything of this order will come from a desire to reduce the prevalence of vitamin D deficiency is unlikely however. There are less expensive options that do not require changing the status quo.

Encouraging increased sun exposure as a strategy for prevention of vitamin D deficiency seems quite simple and inexpensive. This strategy would however require significant education efforts. Although the majority of women reported that they would be willing to spend more time in the sun, 30% were not sure or unwilling. Perhaps those who object to being in the direct sun could be convinced of the value of frequent, short periods of exposure prior to seeking shade or moving indoors.

Although every woman said she would continue to eat a food that is part of her diet if it were fortified with vitamin D or calcium, almost half of the women from Garden Hill and St. Theresa Point felt that they either would not, or did not know if they would, try to eat *more* of that food. It seems likely that the success of a food fortification strategy would depend on the selection of an appropriate food that is consumed in sufficient quantities in the usual diet of most of the people. Passive solutions that do not require lifestyle change or action on the part of the target population are successful if feasible and acceptable. For those who drink milk, the fortification of milk with vitamin D has provided the ideal medium for supplementation.

Calcium and vitamin D could be used to fortify foods common in the north. "Although calcium-fortified flour is available in the north it is not thought to be widely used" (98). An analysis of the potential to use calcium-fortified bannock flour concluded that this would still not be sufficient and would also not reach everyone (98). This analysis did not consider foods other than bannock or adding vitamin D as well, which might increase calcium absorption resulting in greater gains for the same amount of calcium. Food fortification is complicated to plan. The food(s) selected must be common and have a relatively narrow range of variability in rates of consumption. This would ensure that almost everyone gets enough but no one gets too much.

Another route involves the use of high-dose vitamin D, perhaps once a year. This was suggested for Indian-Asian adults in Britain (due to a longstanding problem with vitamin D deficiency, rickets and osteomalacia among this population) following research involving doses of 100,000 IU (122). A high-dose program for pregnant women and infants is currently in place in the Island Lake area. Pregnant women are provided 100,000 IU upon presentation and again at approximately 7 months gestation, and newborns are given 100,000 IU at approximately 6 weeks of age.

This study found greater uncertainty about taking high-dose vitamins than any of the other suggested strategies for prevention. More women reported a willingness to take high-dose vitamin D on the question that asked if they would if they knew they had vitamin D deficiency than when the question was a general one (66 versus 51). Even with the education needs that would accompany this method, a high-dose strategy might be the easiest to administer and most able to reach the most people. Oral vitamin D capsules are extremely inexpensive, but laboratory tests to determine the appropriateness of the supplement or the effect of the supplement are very expensive. If the supplement were to be given to all individuals in target groups (e.g., women of childbearing age, children, or all community members), it would sometimes be given to people who are not deficient. It would be important to understand the effects of the supplement at various baseline serum levels, and the new roles being discovered for vitamin D may mean that more factors need to be considered before this strategy is adopted.

The literature suggests that the vitamin D deficiency may well be secondary to a primary calcium insufficiency. Both increasing sun exposure and a high-dose vitamin D strategy may be limited by an inability to completely redress shortages in calcium consumption. Although food fortification might work well, it is very complicated and unlikely to be practical on a small scale. If it were deemed worthwhile for large populations the government would likely need to play a key role in this strategy. More evidence of the extent and magnitude of the deficiency, and of the extent and severity of consequences will likely be required before this strategy is pursued.

The remaining strategies focus on improving the diet and increasing vitamin consumption. Changes in the Aboriginal diet may have led to a loss of calcium and vitamin D sources that have not been replaced. Given the very small amount of sunlight needed to maintain adequate serum levels of vitamin D in the presence of a healthy diet, the primary deficiency could be calcium. The traditional diet included many more animal sources of calcium, including bone soups, chewed bones (for marrow), bone grease, fish (and their bones), plant sources, and more vitamin D from fish and organ meats. It is very difficult to assess calcium intakes in traditional societies (123). The contribution from a large number of food items is unknown, especially leaves, fruits, and roots.

The contemporary diet has consistently been reported to be low in calcium and vitamin D, principally because milk consumption is low among Aboriginal people. Dairy products are not part of the traditional diet and there are high rates of lactose intolerance among Aboriginal people. Because dairy products are expensive in the north, people may need to be highly motivated to consume expensive foods when less expensive foods may taste better and be more culturally acceptable.

This study found that the majority of pregnant women reported that they like milk, cheese, and other dairy products. This finding, and the belief that milk is good for adults, predisposes attempts to increase milk consumption to success. These findings contradict the preconceived notion that lactose intolerance is an important deterrent to increasing milk consumption among this population. Few women, however, currently drink enough milk to meet daily calcium and vitamin D requirements.

Virtually all women, except those who feel sick after consuming dairy products, reported a willingness to consume more dairy products. This is encouraging, as this is the strategy that has been most successful in Canada so far. A lot of marketing has already been developed for these products, and much of it could be adapted or applied in targeted campaigns.

For most women, the price of milk is the biggest deterrent to drinking more milk. The price of dairy products is prohibitive in northern communities, especially in light of the low incomes of the majority of the families. In Garden Hill, 4 litres of homogenized milk was $10.13 in February 1995, and $11.85 in October 1997. The same product costs less than $4.00 in Winnipeg. As Postl points out, the price of liquor is controlled in Manitoba (124). Although you cannot buy liquor in Garden Hill, if you could it would be the same price as in Winnipeg. Price controls or subsidized nutrition may be cost-effective if they reduce the demand for healthcare.

When asked if they would support efforts to make dairy products more affordable, 86 women said yes, eight said they did not know, and only one said no. Government intervention would be dependent on the ability to demonstrate or predict tangible savings in healthcare and dentistry services. This would require further research and perhaps a demonstration project. The opportunity exists for Band-operated stores to find ways to decrease the price of dairy foods as a matter of policy. In Garden Hill, the Band store has experience with this practice and has increased the price of certain products while decreasing others in order to encourage healthy choices. The price of iron-fortified baby formula was lowered in this way.

Most of the women (75 of 94) were willing to try to find non-dairy dietary sources of vitamin D and calcium. This strategy would require education as to the options available and the quantities required to meet recommended nutrient intake levels. A need for nutrition education is suggested by the inclusion of coffee whitener in the list of milk products by six women from Garden Hill. It is not clear whether this is because the interviewer in Garden Hill includes whitener in her understanding of milk products, whereas the other interviewers do not, or because the individual women showed the whitener to the interviewer because they include whitener in their understanding of milk products. Perhaps the interview question about the use of coffee whitener was interpreted to mean that whitener was a dairy product. The interviewer from Garden Hill did think that whitener was a milk product and she thinks that the women who mentioned it thought so as well. She did not prompt women to show her whitener when asking to see their milk supply. Coffee whitener does not contain any milk powder. The switch from whitener to milk powder may be one way to introduce a small amount of calcium into the diet but it is unlikely to make a significant difference in calcium consumption.

Vitamin and mineral supplements can be encouraged, although nutritionists often recommend only short-term dependence on this method (98). None of the women indicated that they would be unwilling to take vitamins regularly if they learned they were vitamin D deficient, although 10% did not know if they would take vitamins regularly. Vitamins would need to be more successfully promoted than in the past in order to lead to significant changes. The success of any efforts to increase vitamin consumption depends on the ability to convince people of the value of vitamins. Education needs to include information on what vitamins are, and what they do and what they do not do to people. Several women mentioned that vitamins make them eat more and one thought that her baby would be overweight if she took vitamins during pregnancy. These beliefs predispose people to avoid taking vitamins. Improved availability of vitamins and ways to facilitate remembering to take vitamins are two other issues that may need to be addressed if vitamin consumption is to be increased.

For each potential prevention strategy, the information on the predisposing, enabling, and reinforcing factors can guide plans to improve the likelihood of success. Factors are sorted according to whether they are positive, which can be built on, or negative, which need to be overcome (i.e., those that support vitamin D health and those that work against it). Predisposing factors in the current situation of deficiency include the change from the traditional diet to reliance on store foods, and beliefs about vitamins. Enabling factors for the present situation include high food prices, poor access to stores, and even the lack of availability of refrigeration. The normative element of the current diet that includes insufficient calcium and vitamin D is a reinforcing factor.

Predisposing factors that would support better vitamin D status would include increased knowledge and understanding that could result in a belief in the importance of calcium and vitamin D. Existing positive predisposing beliefs can be built on in order to encourage milk consumption. Negative predisposing beliefs could be modified with education in order to encourage vitamin consumption. Enabling factors would include accessible, affordable food options and the skills to acquire sufficient amounts of calcium and vitamin D. Factors such as availability (including cost) can be addressed in order to enable vitamin and milk consumption. Positive feedback from health professionals, a change in the diet norms, improved health and energy, and the absence of rickets would be reinforcing factors. Successful education and marketing would also play a reinforcing role in any prevention strategy.

The PRECEDE-PROCEED framework assumes a form of behaviour change as the goal but does not preclude a medical or policy solution. If the plan was to increase vitamin consumption or put in place price controls, the specific objectives and relevant factors change. All options should be considered. The importance and changeability of the factors will need to be taken into consideration when priorities are established. The choice of methods and materials for program implementation can be based on the factors selected. Intervention strategies differ for each category: direct communications for predisposing factors, indirect communications for reinforcing factors, and community organization, political interventions, and training for enabling factors.

In the open-ended question as to what she would do if she learned she was deficient, almost all of the women from Garden Hill replied "don't know" (15 of 19). In Norway House, 21 of 30 women indicated that they would take vitamins (n=12) or improve their diet (n=9). In St. Theresa Point, half said they would seek professional help from the nursing station. The different ways the three communities answered this question seem to reflect different levels of health awareness or preparedness of individuals to take an active role in their own health.

A greater proportion of women from Garden Hill answered the other open-ended questions with "I don't know" responses as well. It is unclear as to whether this is an artifact of the interviews by this particular research assistant, a local communication norm, or a fundamental difference in knowledge. The Garden Hill interviewer thought that the women did not want to answer but she did not know why. Garden Hill women had significantly lower education attainment and more families were on social assistance. This may indicate a greater need for education in Garden Hill.

This study found reasons for optimism. Encouragement by health professionals seems to be well received and responsible for a substantial amount of the self-reported healthy behaviour. Having books and pamphlets available, and better yet distributing them, may also work. One 16 year old Garden Hill woman, pregnant with her first child, reported that she took vitamins because it said to in the book 'Baby's Best Chance.'

This study is limited by the self-reported nature of the information and the lack of methods to quantify sun, vitamin and diet exposures. The small numbers and lack of variability in the sample limited the ability to perform statistical analyses. Still, the findings are of value for the community members, community leadership, health care professionals and policymakers, as well as for researchers interested in pursuing research into calcium and vitamin D deficiencies and interventions to improve nutritional status.

The results improve our understanding of the beliefs and practices that underlie the current situation of deficiency and could be used to suggest ways to address the problem with a greater likelihood of success than past efforts. In Island Lake, I suggest that community involvement and a multi-faceted strategy that addresses several risk factors is likely to have the greatest effect and may lead to imorovements in overall health status as well as in a reduction in, or the elimination of, rickets. Given the prevalence of vitamin D deficiency in Island Lake and Norway House, the focus should be on improving vitamin D status and not just the elimination of rickets. Rickets may well be the 'tip of the iceberg' (30).

9. POTENTIAL SIGNIFICANCE OF SUBCLINICAL VITAMIN D DEFICIENCY

Finding widespread vitamin D deficiency, not only in Island Lake where it was known but in Norway House where it was not previously expected, may be of increased significance if rickets is not the only relevant consequence of vitamin D deficiency. A substantial body of literature is growing in several fields to suggest that vitamin D deficiency may be of far greater importance than previously thought. Diet and nutrition studies among Aboriginal people consistently report calcium and vitamin D inadequacies. In addition to the literature about Baby-bottle Tooth Decay reviewed in Section 2, the following literature also supports the hypothesis that vitamin D deficiency might be more prevalent and more important than previously thought. Having predicted subclinical deficiency in Norway House, and having found an even more extensive problem than anticipated, makes more pertinent the hypothesis that vitamin D deficiency could underlie common problems.

9.1 Relationship of vitamin D deficiency to conditions other than rickets and osteomalacia:

9.1.1 Susceptibility to infections:

The association of rickets and frequent infection, especially respiratory, has long been recognized and the infections were once thought to cause the rickets (125). More recently, rickets is thought to increase susceptibility to infections (126, 127). One study (126) screened 100 consecutive inpatient children with wheezy bronchitis, and 100 randomly selected age-matched children from the vaccination clinic, for clinical, radiological and biochemical evidence of rickets. The incidence of severe rickets was ten times higher in children with wheezy bronchitis than in controls. That study did not provide evidence of causality and, because rickets is associated with low socioeconomic conditions, those children may have been at increased risk of acquiring wheezy bronchitis due to other socioeconomic determinants of health such as overcrowded housing and malnutrition.

Evidence is accumulating that vitamin D is involved in the immune response (128). Children with rickets displayed defective neutrophil motility that alters the host defence mechanism against bacterial infection (127). It was proposed that the marked deficiency in random motility and directional chemotaxis might have been linked to an increased susceptibility to infection (127). It is unclear how the age-matched healthy controls for that study were selected (and thus it is unknown if they were matched for socioeconomic status). Again, association does not indicate causality and may reflect a common association with an unidentified factor.

Vitamin D has a regulatory effect on cell growth and proliferation, and analogues that can produce anti-tumour effects without toxicity are being developed (33). A synthetic analogue is used to treat psoriasis (12, 129). A number of interactions have been discovered *in vitro* but their relevance to *in vivo* immune mechanisms is unclear (32). Certainly a lack of vitamin D is associated with an increased risk of infection while vitamin D is associated with positive immune responses.

9.1.2 Osteoporosis:

Vitamin D deficiency in adults may lead to secondary hyperparathyroidism and increased bone loss, thus causing or aggravating osteoporosis (130). Compared to Caucasian women, bone density was significantly lower in postmenopausal Aboriginal women from southwestern Ontario (131). Lower bone mineral contents and earlier and more rapid bone loss in adult Inuit relative to Caucasians has also been found (132-134). Whether or not there is a genetic predisposition to osteoporosis based on vitamin D receptor polymorphism is unclear. Bone mineral density is under strong genetic control and recent research in twins has suggested that vitamin D receptor gene polymorphism accounts for as much as 75% of the genetic effect (135). Several studies have found this relationship while others have not (136). Possibly, vitamin D receptor polymorphism interacts with other genes and the environment, including vitamin D sufficiency and calcium intake (137).

Normal values for circulating 25-hydroxyvitamin D, the metabolite used to measure vitamin D status, are unknown and extremely difficult to determine due to the influence of latitude, season, atmospheric conditions, diet, clothing, age, sunscreens, and lifestyle (138). Instead, usual values are applied. Those values that have not yet been associated with ill effects are considered the lower limit of normal. This lower limit is given variously as between 25 to 40 nmol per litre (10 to 16 ng per millilitre). Heaney (138) suggests that this might still be too low to define "normal". Although levels greater than 20 nmol/L are rarely associated with histologically confirmed osteomalacia, this does not make them normal. Bone mineral density research has determined that people with values less than 80 nmol/L exhibit physiological differences that are reversed by daily administration of 400 to 800 IU of vitamin D. The same doses given to the people with levels over 80 nmol/L had no effect (138). "Normal" values were determined when vitamin D was thought to be relevant only to calcium homeostasis and an absence of rickets and osteomalacia was considered equivalent to health. With the identification of new roles for vitamin D it is necessary to re-evaluate the concept of normality and what is, and what is not, healthy.

9.1.3 Insulin secretion and diabetes:

Production of the active hormonal form of vitamin D is regulated by parathyroid hormone, growth hormone, prolactin, estrogens, thyroid hormones, and insulin (139). A feedback loop between vitamin D and insulin has been discovered (140) and this may be of particular significance in areas with high rates of diabetes. Animal studies have shown that vitamin D has a role in pancreatic β cell function and that glucose affects vitamin D metabolism (140-144). Vitamin D-deficient rats exhibited impaired insulin secretion (142). Repletion led to increased insulin and plasma calcium levels, but the vehicle alone had no effect on controls (140). Vitamin D-deficient rabbits also have reduced insulin secretion and impaired glucose tolerance, and these abnormalities were reversed by vitamin D therapy, but not by acute changes in serum calcium (145).

Studies on humans have also shown an association between vitamin D deficiency and reduced insulin secretion (139, 146, 147). In one study of 10 treated epileptic patients and 15 geriatric patients, two weeks of vitamin D therapy corrected subclinical vitamin D deficiency but did not enhance insulin secretion or improve glucose tolerance (139). In another study, four adult women with symptomatic vitamin D deficiency (bone pain, difficulty walking) and radiographically confirmed osteomalacia, were treated with vitamin D daily for six months and compared to 10 healthy subjects (146). That study found impaired pancreatic response to glucose during vitamin D deficiency. Another study provided vitamin D for 4 days to 35 otherwise healthy diabetic subjects and did not find an effect on glucose homeostasis (148). The difference in results may be related to differing degrees of deficiency and lengths of repletion. Vitamin D was found to influence glucose metabolism of 12 women with gestational diabetes (149).

Evidence is accumulating that "hypovitaminosis D may be a significant risk factor for glucose intolerance" (147). The etiology of diabetes is not understood and there are currently no effective strategies for primary prevention. The risk factors considered most important for non-insulin dependent diabetes mellitus in developed nations (obesity and a sedentary lifestyle) do not hold in an international perspective, where 'malnutrition-related diabetes mellitus' exists and a large proportion of non-insulin dependent diabetes mellitus patients in tropical countries are very lean (150).

If vitamin D deficiency is contributing to the risk of developing diabetes, this could be especially significant in the Island Lake area. It seems that Garden Hill has the highest rates of vitamin D deficiency in Manitoba and also has very high rates of diabetes. Of Aboriginal adults (over age 25) with treaty status in Manitoba, 20% of women and 12% of men had diabetes in 1991, compared to a provincial figure of 6.7%; the five year increase in prevalence was over 40% in women and 50% in men (151).

There is also an alarming situation in Garden Hill wherein individuals are developing what is considered to be adult onset diabetes (non-insulin dependent diabetes mellitus) at very young ages (before age 20) in increasing numbers (152). In a 1992 report of non-insulin dependent diabetes mellitus in Indian children less than 15 years of age in Manitoba between 1984 and 1990, 11 of 20 children were born in Garden Hill or St. Theresa Point in the Island Lake area, while eight were from scattered communities and the birthplace of one was unknown (153).

The Diabetes Education Resource For Children and Adolescents in Manitoba has found that approximately 1.5% of children with Type I diabetes (insulin dependent diabetes mellitus) are Treaty Indian, but 100% of known children with Type II diabetes (non-insulin dependent diabetes mellitus) are Treaty Indian (154). The prevalence of non-insulin dependent diabetes mellitus is also two to six times higher for minority populations (Black, Hispanic, Native American, Asian, and Pacific Islander) in the United States (155).

Research into the hereditary predisposition to diabetes has led to an association between group-specific component (Gc) proteins (vitamin D receptors now known as VDR) and fasting insulin levels (156). Gc proteins are human plasma proteins that are synthesized in the liver, appearing early in fetal life (157). They have a worldwide polymorphism and while two alleles (Gc1 and Gc2) are found in all human populations, a number of variants exist (157). Gc alleles are likely inherited in an autosomal, codominant fashion (158). Szathmary (156) found that after adjusting for Body Mass Index, Gc genotype was the only variable that had a significant effect on fasting insulin level in Dogrib Indians. She suggested that Gc concentration by phenotype might have consequences for vitamin D concentration.

Vitamin D prevents the development of diabetes mellitus in an animal model of insulin-dependent diabetes (IDDM). A study of allelic variation in vitamin D receptors in an Indian Asian population in Britain found evidence of an association of one receptor allele with IDDM susceptibility (159).

High rates of rickets and osteomalacia have been apparent in the south Asian population in Britain for decades. This population also has non-insulin dependent diabetes mellitus rates that are at least four times those of Caucasians and has an earlier age at onset (160). Provision of 100,000 IU of vitamin D to subjects 'at-risk' and at 'low-risk' for diabetes did not correct abnormal glucose tolerance. However, the authors suggested that early and sustained repletion with vitamin D should be studied for its value in diabetes prevention in communities where hypovitaminosis D is common.

A study of the prevalence of diabetes, hyperinsulinaemia, and associated abnormalities in immigrant Asians, Asians in India, and native white British men found a higher prevalence of diabetes and impaired glucose tolerance for Asians, although the Asian patients and controls were more active (161). In 1993, The World Health Organization declared diabetes a global health problem, with populations of developing countries, minority groups, and disadvantaged communities in industrialized countries facing the greatest risk (162). If vitamin D deficiency has a role in diabetes, the potential for effective and inexpensive prophylaxis exists.

9.1.4 Hypertension, Syndrome X and cardiovascular disease:

Low calcium intakes have been recently accepted as a risk factor for hypertension (163, 164). The term Syndrome X is used to describe the clustering of metabolic abnormalities that have been associated with insulin resistance and are thought to cause cardiovascular disease (165). The metabolic abnormalities considered part of the syndrome are hypertriglyceridemia, hypertension, low high density lipoprotein cholesterol, and impaired glucose metabolism (165). Deaths from cardiovascular disease are higher in people with non-insulin dependent diabetes mellitus than in the general population (166). Most people who die from cardiovascular disease have one to three of the syndrome X abnormalities (165). As vitamin D deficiency is involved in a feedback loop with insulin production, and deficient insulin production is hypothesized to underlie at least one form of early onset non-insulin dependent-diabetes (167), calcium and vitamin D deficiency may be a common link in the metabolic disorders recently referred to as 'Syndrome X' (168).

9.1.5 Cancer:

Recently, an excess colorectal cancer risk has been found for people with diabetes mellitus (169). Both low vitamin D and low calcium have been associated with increased risk for several cancers, including breast, prostate and colorectal (170, 171). Vitamin D has a role in the growth regulation of human cancer cells. Vitamin D receptor levels increase in response to vitamin D and a loss of receptivity is associated with malignancy (172). Tumours have lower levels of vitamin D receptors (173) and after vitamin D therapy, tumour cells are less proliferative and differentiation is enhanced (174). VDR allelic polymorphisms are associated with Vitamin D Receptor levels and vitamin D serum levels. For men with low vitamin D status, risk of prostate cancer was influenced by their vitamin D receptor genotype (175). Vitamin D receptor genotype was also associated with the risk of developing metastases in women with breast cancer (176).

9.2 Relevance:

The vitamin D deficiency among Aboriginal people may well be of a continuous nature as the adequacy of the mother's status during pregnancy will affect the developing child and determine the birth stores. Diet studies indicate that the diet of Aboriginal children and adults is calcium- and vitamin-D deficient. It is possible that children born to vitamin D-deficient mothers have defective teeth that are susceptible to devastation by sugar and bacteria. Theoretically, the prenatal or lifelong vitamin D deficiency could also lead to metabolic impairments that lead to diabetes and other disorders related to low calcium. Thus, healthy vitamin D status could theoretically be important for diabetes prevention.

There is a substantial body of literature building from a debate as to whether socioeconomic status during early life and fetal malnutrition have lifelong consequences for conditions such as diabetes, hypertension and cardiovascular disease (168, 177-184). A recent clinical review in the British Medical Journal reported that fetal malnutrition may impair fetal growth and reduce the β cell mass of the pancreas, thus contributing to the later development of non-insulin dependent diabetes mellitus (185). Vitamin D deficiency may have a role in this fetal malnutrition. Improvement in the diet and increased vitamin consumption are likely to result in numerous improvements in health and quality of life. Increased energy and improved health, even for conditions for which the etiology is not well understood, may accompany improved nutrition. Biological plausibility and numerous associations support a role for vitamin D deficiency in several important conditions including diabetes, cardiovascular disease, cancer and caries.

The potential to intervene in any of the above-mentioned disease pathways is worth pursuing. In an editorial in a recent British Medical Journal, hypovitaminosis D was described as a common and neglected problem that can be corrected safely, effectively and inexpensively, although uncertainty exists as to the best approach to prevention (186). A better understanding of the extent and magnitude of vitamin D deficiency, the risk factors for vitamin D deficiency, and the relevance of subclinical deficiency will be important for planning prevention.

10. FUTURE RESEARCH

Before data collection for this study began, ethical approval, community consent and individual informed consent was obtained to analyze the genotypes of two vitamin D receptors from the blood samples of the women who participated in this study, as part of another study. When it is available, the genotype data will be linked to the data from this study and the genotypes will be analyzed for their association with the other variables collected in this study, including 25-hydroxyvitamin D concentrations.

Developing from the hypothesis that vitamin D deficiency might underlie Baby-bottle Tooth Decay, a study is currently underway in Garden Hill. The dental health of the children in Garden Hill who received high-dose vitamin D supplements during gestation or in infancy is being compared to that of children who were not exposed to the high-dose vitamin D supplements.

Further research into the extent and magnitude of vitamin D deficiency in other populations is needed, as well as research into the consequences of vitamin D deficiency and its role in diseases other than rickets, osteomalacia, and osteoporosis. The opportunity exists for prevention intervention trials. Certainly, disease causation is multifactoral and association is not causation, but observations of association can lead to effective prevention even when the pathogenesis is not well understood.

11. CONCLUSION

The incidence of clinical rickets was significantly higher in the Island Lake area than in Norway House for the 1993 to 1994 birth cohort. There were 15 cases of rickets identified from Garden Hill and 5 from St. Theresa Point for an incidence rate of 85/1000 for Garden Hill and 55/1000 for St. Theresa Point. No cases of rickets were identified from Norway House. There were several children from the Island Lake area who may also have had clinical rickets but did not meet the inclusion criteria for this study.

Widespread vitamin D deficiency among the pregnant women assessed from all three communities, including Norway House where vitamin D deficiency was not known to be a problem. Overall, 84.6% of the pregnant women studied had vitamin D deficiency. A significant difference in median values was found between Garden Hill and Norway House. The prevalence was highest in St. Theresa Point (91.4%) where the estimated recruitment was highest and the median value was intermediate (21 nmol per litre). The prevalence was intermediate in Garden Hill (84.4%) where the median value (18 nmol per litre) was the lowest and the estimated recruitment was lowest. The prevalence was lowest and the median value highest in Norway House (78.4% and 24 nmol per litre). These findings support the hypothesis that vitamin D deficiency is prevalent among pregnant women in all three communities but that the extent and magnitude are greater in the Island Lake area. The difference in rickets rates also supports the hypothesis that the magnitude of the deficiency problem is greater in Island Lake.

The high prevalence of deficiency in Norway House meant that the three communities were very similar. This homogeneity of outcome precluded the use of logistic regression modeling with vitamin D deficiency or community as the dependent variable (outcome). However, univariate comparisons found significant differences between Garden Hill and Norway House for several known risk factors that might explain the difference in vitamin D deficiency and rickets rates.

In Garden Hill, women reported less frequent wearing of shorts or skirts, and less time spent in the sun. These factors could contribute to reduced vitamin D synthesis due to reduced exposure to sunlight. Garden Hill women also reported lower consumption of calcium-containing and other nutritious foods and poorer knowledge about vitamins. These differences may explain why the prevalence and magnitude of vitamin D deficiency is greater among pregnant women in Garden Hill.

The factors that might explain why children in Garden Hill are at risk for rickets while those in Norway House are not, despite widespread vitamin D deficiency in both communities pertain to differences in infant care. From the serum prevalence data, it is possible that many babies in Norway House are born with stores of vitamin D that are just as inadequate as those of many babies born in Garden Hill. Perhaps the significant differences in age at introduction of milk or formula, and in rates of provision of vitamins and evaporated/whole milk to babies makes the difference as to whether or not a child develops clinical rickets.

In Garden Hill, compared to Norway House, fewer babies were given vitamins and evaporated/whole milk. Also, most babies in Garden Hill were not introduced to vitamin D-fortified milk/formula until after six months of age while in Norway House the majority of children began receiving milk/formula before six months of age. Although the local use of the tikinagon (an infant carrier that involves swaddling) in Garden Hill may play a role in restricting sun exposure, it might not be contributing to an increased likelihood of rickets there compared to Norway House. The majority of women from both Garden Hill and Norway House reported that when their babies are outside in the summer, only their hands and face are exposed to the sun.

Social and cultural factors were investigated using questions about beliefs and practices. This information was used to identify specific predisposing, enabling and reinforcing factors that aid in understanding the changeability of the risk factors. The results will be shared with the communities and guide prevention planning. A multi-faceted approach that works on several risk factors simultaneously may have the best result and lead to improved health and nutrition beyond that specific to vitamin D. Existing positive predisposing beliefs, such as the belief that milk is good for adults, can be built on in order to encourage milk consumption and to develop an understanding of the importance of calcium and vitamin D. Negative predisposing beliefs can be modified with education in order to encourage vitamin consumption. Enabling factors will need to be encouraged, such as the development of accessible, affordable food options and the skills to acquire sufficient amounts of calcium and vitamin D. Factors such as availability (including cost) can be addressed in order to enable vitamin and milk consumption. Positive feedback from health professionals, a change in the diet norms, improved health and energy, and the absence of rickets would become reinforcing factors. Successful education and marketing would also play a reinforcing role in any prevention strategy.

It is proposed that vitamin D deficiency is widespread among Aboriginal people in North America, of hitherto unrecognized import, and offers an important potential avenue for prevention of early childhood caries and non-insulin dependent diabetes, and possibly other diseases such as cardiovascular disease and caries as well. It appears that very little research has pursued the link between vitamin D and these other conditions, perhaps because vitamin D deficiency is not considered to be a significant problem in

North America. Research has recently begun to focus on the relationship of vitamin D to osteoporosis and widespread vitamin D deficiency has been identified among the elderly. There is evidence to suggest that subclinical vitamin D deficiency may be common among Aboriginal people in Canada. Evidence of biological plausibility for a role for vitamin D in several important conditions is accumulating. The need for research to determine the significance of vitamin D sufficiency throughout life is compelling given the epidemics of Baby-bottle Tooth Decay and non-insulin dependent diabetes mellitus epidemics among Aboriginal people and the preventable nature of vitamin D deficiency.

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Appendix 1: Selection of Study Communities

Historically the four communities of Garden Hill, St. Theresa Point, Red Sucker Lake and Wasagamack were known as the Island Lake Band. With more permanent settlement into the four locations, individual band status was accorded by the Department of Indian Affairs. These four Bands formed the Island Lake Tribal Council. It was when the Catholic and United Churches were built at remote locations, that Garden Hill and St. Theresa Point developed, split along religious lines. St. Theresa Point is a predominantly Catholic and Garden Hill is predominantly Protestant.

The Island Lake area was known to have the highest rates of rickets in Manitoba. Garden Hill was thought by health professionals to have the highest rates, and rates in St. Theresa Point were thought to have declined in recent years. Red Sucker Lake and Wasagamack have too few births per year (18 and 36 respectively in 1993 according to Medical Services Branch records), from a statistical and logistical viewpoint, to be included in the study. Garden Hill and St. Theresa Point (with 107 and 68 births, respectively, in 1993) were both selected for study. Because Garden Hill and St. Theresa Point seemed to have different rates, comparisons of rates and risk factors between the two communities could aid understanding.

At the time this study was being prepared there were no cases of rickets from Norway House that were known to the health professionals, including Dr. Moffatt (my supervisor), a pediatrician who held clinics there over the past two decades. Because of the role of sunlight in vitamin D health, it was important to pick a comparison community that was at the same latitude as Garden Hill and St. Theresa

Point (53.90N). This would control for potential UVB exposure, although it would not address local variations in cloud cover. In 1993, there were 127 births in 1993 in Norway House according to Medical Services Branch records.

Garden Hill, St. Theresa Point and Norway House had large enough populations to support finding differences in rickets and vitamin D deficiency rates (see population figures below and sample size calculations in Appendix 2). The differences between Island Lake and Norway House may reflect genetic differences, but this is not as likely between Garden Hill and St. Theresa Point. The Island Lake bands share the same ancestry, whereas Norway House and Island Lake are unrelated peoples. Norway House Band are Cree-speaking. Island Lake Bands speak Island Lake Dialect which is distinct from both Cree to the west and Ojibway to the east.

Estimated On-reserve population (November 1993, Medical Services Branch):

Island Lake:	Garden Hill	2377
	St. Theresa Point	2110
	Red Sucker Lake	529
	Wasagamack	979
Norway House:		3191

Appendix 2: A Priori Sample Size Calculations & Power Analysis

Multiple Logistic Regression:

Based on the method described by Hsieh FY. Sample size tables for logistic regression. Statistics in Medicine. 1989;8:795-802.

This method does not require knowledge of the number of covariates.

Covariate of Interest: Milk consumption

Assumptions:

> Average milk consumption (based on a St. Theresa survey conducted by the Nursing Caries Committee): 6 cups/week=1.5 L
> 3 L will provide adequate calcium
> 3 L plus sun will provide enough vitamin D

Range of probability of vitamin D deficiency:

> P=0 at 3 L
> P=1 at 0 L
> P=.5 at 1.5 L

Probability of vitamin D deficiency at the mean value of the covariate of interest:

> P=.5

Odds ratio of deficiency corresponding to an increase of 1 standard deviation from mean: (r=.85/.5=1.7) r=1.7

Using Table II: alpha = .05, beta = .80   Sample size is 103.

Thus sample size would be 35 in each of three communities to permit multiple logistic regression to estimates odds ratios for risk factors associated with vitamin D deficiency.

Power to Detect Prevalence Differences:

Using sample size calculated in a), Chi-squared test of expected vitamin D deficiency rates, Norway House and Garden Hill:

Using 1987 data, there is a 76% prevalence of maternal vitamin D deficiency in Island Lake. For Norway House, which has no rickets problem, but might have high rates of subclinical vitamin D deficiency, assume an estimated prevalence of 55%. With 35 samples from Norway House and 70 from Island Lake (Garden Hill and St. Theresa):

If Garden Hill was the same as Norway House:

Observed:	Norway House	Garden Hill	Expected Garden Hill
Vit D deficient	19	53	38
Not Deficient	16	17	

$$\frac{(O-E)^2}{E} = \frac{(53-38)^2}{38} = 5.92$$ Chi square (critical) = 3.84

a) With 35 samples from Norway House and 70 from Island Lake, if the rate is 75% in Island Lake and 55% in Norway House, a significant difference would be found.

Appendix 3: Laboratory Test Information and Normal Values

Laboratory services were purchased from Diagnostic Laboratory and Radiology Services, Department of Clinical Chemistry, Health Sciences Centre, Winnipeg, Manitoba.

Serum Test	**Normal Values**	**Kit**
Calcium	2.20 to 2.60 mmol/L	Boehringer Mannheim Systems 1 551 272; 1 730 240
Inorganic Phosphorus UV test for phosphate	0.81 to 1.45 mmol/L	Boehringer Mannheim Systems 1 551 388; 1 730 347
Alkaline Phosphatase (AMP buffer)	30 to 120 U/L adults 59 to 422 U/L 12 to 17 years	BM/Hitachi 917 Systems Pack 1557 033
25-hydroxyvitamin D	35 to 105 nmol/L	INCSTAR ^{125}I 25-OH Vitamin D RIA Cat. No. 68100

Ca

Calcium

Boehringer Mannheim Systems

1 551 272
9 x 45 ml solution 1 (R 1) and 9 x 10.5 ml starter reagent (R 2)

1 730 240
6 x 63 ml solution 1 (R 1) and 6 x 28 ml starter reagent (R 2)

Contents

	1 551 272	1 730 240
1 Buffer	9 x 45 ml	6 x 63 ml
2 Chromogen	9 x 10.5 ml	6 x 28 ml

Also required
Calibrator for automated systems

Recommended quality control
Accuracy: Precinorm® U, Precipath® U
Precision: Precinorm® UPX

Preparation and stability of solutions
1 551 272/1 730 240
R 1
1 Buffer
Use contents as supplied.
Stable for 3 months in the instrument at approx. +10°C
R 2 (Starter reagent)
2 Chromogen
Use contents as supplied.
Stable for 3 months in the instrument at approx. +10°C

Sample material
Serum, heparinized plasma, urine
Stability in serum:
10 days at +4 to 25°C
6 months at -20°C

Instrument settings
If necessary, use the application disk to read in the instrument settings.

Method[1]
o-Cresolphthalein complexone

Test principle
Ca^{2+} forms a violet complex with o-cresolphthalein complexone in alkaline solution.

Measuring range
Dilution threshold
Serum/plasma: 5.00 mmol/l (20 mg/dl)
Urine: 13.00 mmol/l (52 mg/dl)
To convert to mg/dl, multiply the value in mmol/l by a factor of 4.

Interferences
EDTA plasma causes depressed results.

Please note
For tests on 24-hour urine, multiply the value obtained by the 24-hour urine volume.

Reference values
Serum/plasma[2]
2.15–2.55 mmol/l (8.60–10.2 mg/dl)

For reference ranges in children, see brochure by Heil W, Schuckließ F and Zawta B, eds. Reference Ranges for Adults and Children. Pre-analytical Considerations - 1995, published by Boehringer Mannheim GmbH.

1st morning urine[3]
1.30–8.93 mmol/l (5.20–35.7 mg/dl)

24-hour urine[4]
2.5–8.0 mmol/24 h (100–320 mg/24 h) corresponding to
1.7–5.3 mmol/l* (6.7–21.3 mg/dl*)
* calculated from a urine volume of 1.5 l/24 h

Initial concentrations of solutions
1 Ethanolamine buffer: 1 mol/l, pH 10.6
2 o-Cresolphthalein complexone: 0.30 mmol/l; 8-hydroxyquinoline: 13.8 mmol/l; hydrochloric acid: 122 mmol/l

Concentrations in the test
Ethanolamine buffer: 0.73 mol/l, pH 10.6; o-cresolphthalein complexone: 0.08 mmol/l; 8-hydroxyquinoline: 3.4 mmol/l; hydrochloric acid: 30 mmol/l

References

1 Gindler EM, King JD. Am J Clin Pathol 1972;56:376.
2 Gosling P. Analytical reviews in clinical biochemistry: Calcium measurement. Ann Clin Biochem 1986;23:146.
3 Krieg M et al. J Clin Chem Clin Biochem 1986;24:863.
4 Keller H, ed. Klinisch-chemische Labordiagnostik für die Praxis. 2nd ed. Stuttgart/New York: Georg Thieme Verlag, 1991:213.

[illegible]

PHOS

Inorganic Phosphorus
UV test for phosphate

Boehringer Mannheim Systems

1 551 388
9 x 41 ml solution 1 (R 1) and 9 x 18.5 ml starter reagent (R 2)

1 730 347
6 x 63 ml solution 1 (R 1) and 6 x 31.5 ml starter reagent (R 2)

Contents

	1 551 388	1 730 347
1 Blank reagent	9 x 41 ml	6 x 63 ml
2 Phosphate reagent	9 x 18.5 ml	6 x 31.5 ml

Also required
Calibrator for automated systems

Recommended quality control
Accuracy: Precinorm® U, Precipath® U
Precision: Precinorm® UPX

Preparation and stability of solutions
1551388/1730347
R 1
1 Blank reagent
Use contents as supplied.
Stable for 3 months in the instrument at approx. +10°C
R 2 (Starter reagent)
2 Phosphate reagent
Use contents as supplied.
Stable for 3 months in the instrument at approx. +10°C

Sample material
Serum; plasma treated with heparin, EDTA or fluoride; urine
Stability in serum/plasma: 8 hours at +20 to 25°C
24 hours at +4°C
1 year at −20°C if frozen once

Instrument settings
If necessary, use the application disk to read in the instrument settings.

Method[1]
Molybdate reaction

Test principle
Inorganic phosphates react with ammonium molybdate in sulfuric acid solution to form an ammonium phosphomolybdate complex.

Measuring range
Dilution threshold
Serum/plasma: 20 mg/dl (6.46 mmol/l)
Urine: 285 mg/dl (92 mmol/l)

Please note
For investigations on 24-hour urine, multiply the value obtained by the 24-hour urine volume.

Reference values
Serum/plasma[2]
2.7–4.5 mg/dl (0.87–1.45 mmol/l)
24-hour urine[3]
340–1000 mg/24 h (11–32 mmol/24 h) corresponding to 23–67 mg/dl* (7.3–21.3 mmol/l*)
* Calculated from a urine volume of 1.5 l/24 h

Initial concentrations of solutions
1 Blank reagent
Sulfuric acid: 0.36 mol/l; detergent
2 Phosphate reagent
Ammonium molybdate: 3.5 mmol/l; sulfuric acid: 0.36 mol/l; sodium chloride: 150 mmol/l

Concentrations in the test
Ammonium molybdate: 1.0 mmol/l; sulfuric acid: 0.36 mol/l; sodium chloride: 44 mmol/l; detergent

References

1 Henry RJ, ed. Clinical Chemistry, 2nd ed. Hagerstown: Harper & Row, 1974:773.
2 Burtis CA, Ashwood ER, eds. Tietz Textbook of Clinical Chemistry, 2nd ed. Philadelphia: WB Saunders, 1994:1909.
3 Henry RJ, ed. Clinical Chemistry, 2nd ed. Hagerstown: Harper & Row, 1974:728.

ALP

Alkaline Phosphatase (AMP-buffer)

EC 3.1.3.1

BM/Hitachi 917 Systems Pack
1557 033
for 5 x 50 ml reagent (R 1) and 4 x 12.6 ml starter reagent (R 3)

Contents
1 Buffer (5 x 50 ml)
1a Mg^{2+} (1 x 10 ml reagent tablets)
2 Substrate (4 x 6 reagent tablets)

Also required:
Calibrator for automated systems

Recommended quality control:
Accuracy: Precinorm® U, Precinorm® E, Precipath® U, Precipath® E
Precision: Precinorm® UPX

Preparation and stability of solutions

R 1

1 **Reagent (buffer/Mg^{2+})**
Place 2 reagent tablets from bottle 1a in one bottle 1.
Dissolve by gentle swirling.
Stable for 7 days in the instrument (at approx. +10°C)
Use one bottle of ready-to-use reagent (R 1) to prepare the starter reagent.
Stable for 4 weeks in a closed bottle at +2 to 8°C

R 3 (starter reagent)

2 **Reagent/substrate (*p*-nitrophenyl phosphate)**
Dissolve the contents of the bottle (6 reagent tablets) by filling up to mark with ready-to-use reagent (R 1).
Stable for 7 days in the instrument (at approx. +10°C)
Store protected from light!

Sample material
Serum or heparinized plasma
Activity decrease in serum after 7 days:
0% at +4°C 10% at +20 to 25°C

Instrument settings
If necessary, use the application disk to read in the instrument settings.

Method
Commission Enzymologie. (1977). *Ann. Biol. clin.* 35: 271
Medeadelingenblad N.V.K.C. (1978). 4: 314

Test principle
p-nitrophenyl phosphate + $H_2O \xrightarrow{AP}$ phosphate + *p*-nitrophenol

Measuring range
Dilution threshold: 500 U/l (8.34 µkat/l)
1 U = 16.67 x 10^{-3} µkat

Interference
Hemolysis interferes with the test.

Normal values

		25°C*	30°C*	37°C*
Adults	U/l	23–70	30–90	39–117
	µkat/l	0.38–1.17	0.50–1.50	0.65–1.95

*Calculated values

The factors used to convert normal values from 30°C to assay temperature are 0.78 (25°C) and 1.30 (37°C).

Initial concentration of solutions
1 2-Amino-2-methyl-1-propanol: 0.92 mol/l, pH 10.5; Mg^{2+}: 0.91 mmol/l
2 *p*-Nitrophenyl phosphate: ≥ 100 mmol/l; 2-amino-2-methyl-1-propanol: 0.92 mol/l, pH 10.5; Mg^{2+}: 0.91 mmol/l

Concentrations in the test
2-Amino-2-methyl-1-propanol: 0.89 mol/l, pH 10.5;
Mg^{2+}: 0.89 mmol/l; *p*-nitrophenyl phosphate: 16 mmol/l

Reference
1 Mathieu, M. et al. (1980). Page 45 in: *L'Information Scientifique du Biologiste*

May [illegible]

BOEHRINGER MANNHEIM

[illegible]

[illegible]

[illegible]

[illegible]

VitD split from VitD Binding Protein with alcohol mixture

* 100 µl std, cont or sample

1.2 ml Alcohol mixture

20 mins on ice

Centrifuge 15 mins @ 2-8°C

[illegible]

50 µl above supernatant

20 µl ^{3}H 25-OH-D

500 µl VitD binding Protein

3 hour incubation @ 2-8°C

[illegible]

100µl Dextran Coated Charcoal Suspension

20 min incubation @RT

Centrifuge 20 mins @ 2-8°C

Supernatant to Scintillation Fluid

Count on Scintillation Counter

reported sensitivity 5.5 nmol/L

[illegible]

Extraction

VitD split from VitD Binding Protein with acetonitrile

* 50 µl std, cont or sample

500 µl acetonitrile

Vortex 10 secs.

Centrifuge 10 mins @ RT

[illegible]

25 µl above supernatant

50 µl ^{125}I 25-OH-D

1.0 ml Goat anti 25-OH-D

90 min incubation @ RT

[illegible]

500 µl Donkey anti-Goat Precipitating complex

20 min incubation @RT

Centrifuge 20 mins @ RT

Decant immediately to waste

Count tubes on gamma counter

reported sensitivity 7 nmol/L

Observed = 12.5 nmol/L

Appendix 4: Laboratory Research and Development Test Results for Vitamin D Kit

- 1 -

R & D Summary: Evaluation of INCSTAR ^{125}I 25-Hydroxyvitamin D RIA Kit

February, 1996
EF/BD/PD

Purpose:

To evaluate the INCSTAR ^{125}I 25-OH Vitamin D kit as a potential replacement method for the current HPLC analysis performed by Mayo Clinic Laboratories. Preliminary data from INCSTAR indicated excellent method correlation, significant cost savings ($85 vs $231 per patient) and markedly reduced specimen volume requirements (100 µL vs 2.0 mL)

References:

INCSTAR ^{125}I 25-OH Vitamin D RIA Kit insert.Cat # 68100

Hollis, Bruce W. et al. Determination of Vitamin D Status by Radioimmunoassay Using an [^{125}I] - Labelled Tracer. Clinical Chemistry, April 1996 (In Press)

Benucci A, et al. Serum 25-Hydroxyvitamin D levels in normal subjects: Seasonal variations and relationships with parathyroid hormone and osteocalcin. The Journal of Nuclear Biology and Medicine 1993; Vol 37; No 2: 77-82

Technical Bulletin, INCSTAR Corporation: Lorenz, J. Comparison Studies ^{125}I 25-OH-D RIA INCSTAR Cat. No 68100.

Methodology:

INCSTAR Procedure:
This is a two step procedure. The first step involves a rapid extraction of 25-OH Vitamin D from serum using acetonitrile. Following extraction, the treated sample is then assayed using an equilibrium RIA procedure. The RIA method is based on an antibody with specificity to 25-OH Vitamin D. The sample, antibody and ^{125}I tracer are incubated for 90 minutes at 20-25°C. Phase separation is accomplished after 20 minute incubation at 20-25°C with a second antibody precipitating complex. This method does not distinguish between 25-OH Vitamin D_3 (derived mainly from the action of ultraviolet light on the skin) and 25-OH Vitamin D_2 (from dietary sources).

Mayo Clinic Laboratory Procedure:
The vitamin D metabolites are extracted from serum by using a dual cartridge system utilizing both reverse phase and normal phase liquid chromatography. Quantitation is by ultraviolet absorption following normal phase high-performance liquid chromatography. The Mayo method distinguishes between 25-OH Vitamin D_3 and 25-OH Vitamin D_2.

Conclusion:

The INCSTAR ^{125}I 25-OH Vitamin D RIA Kit correlates well with the Mayo HPLC method for total 25-OH Vitamin D. The reference range is comparable with both methods. The lower limit of sensitivity for the INCSTAR kit is approximately 12 nmol/L. This should be adequate to determine nutritional status of both adult and pediatric patients.

Implementation Recommendation:

The INCSTAR ^{125}I 25-OH Vitamin D assay should be implemented as soon as possible. Potential annual savings of approximately $14,000 will result. The initial level of service should be biweekly with subsequent review based upon workload evaluation and clinical need.

Precision

Within-Run Precision

June 12, 1995 (1st assay)
Kit Low Control: nmol/L

n =	10
mean =	34.59
s.d. =	3.77
c.v. =	10.9%

November, 1995 (8th assay)
Normal Serum: nmol/L

n =	6
mean =	61.07
s.d. =	7.77
c.v. =	12.7%

Day to Day Precision

Kit Controls: Same lot number analysed over a period of 5 months in 6 runs with 5 different kit lot numbers.

	Low Control	Hi Control
n =	14	14
mean =	37.49	130.99
s.d. =	4.396	26.101
c.v. =	11.7%	19.9%

Normal serum sample: Analysed over a period of 2 months, in 4 runs with 3 different kit lot numbers.

n =	7
mean =	56.20
s.d. =	6.233
c.v. =	11.1%

These results are consistent with the precision data in the kit insert.

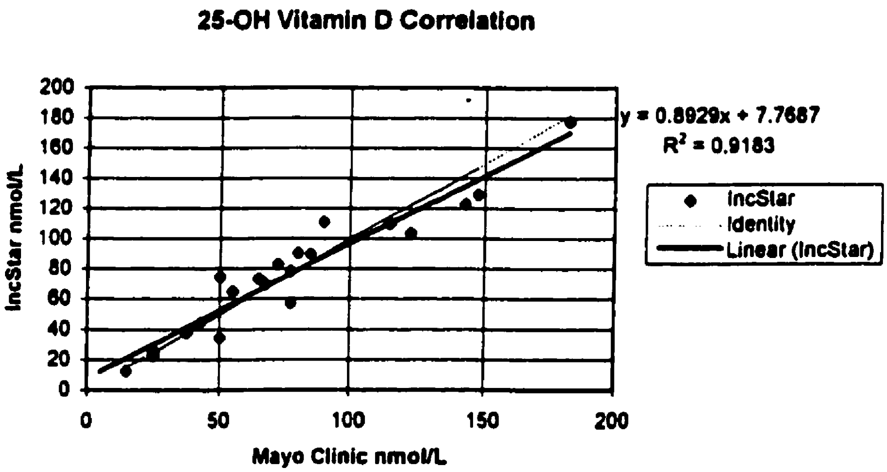
Correlation:

When we began running the INCSTAR kit we kept the acetonitrile and extraction tubes on ice to reduce the potential evaporation of acetonitrile during the extraction process. Our results were about 66% of Mayo Clinic results. With extraction at room temperature the correlation improved to about 90%.

Split sample correlation with Mayo Clinic Laboratory procedure was acceptable with one discordant specimen:

Mayo Clinic Lab Result	120 nmol/L
HSC Result	15 nmol/L (1st extraction)
	21 nmol/L (2nd extraction)

There was insufficient specimen to reassay the sample by either assay. It was excluded from the statistical analysis.



Correlation: Patient Data

Vitamin D Patient Samples		
	nmol/L	
ID#	**D25_Mayo**	**IncStar**
49948	55	65
56323	85	90
69596	80	90
67677	37	38
80408	42	44
41034	65	73
97225	142	123
66005	25	22
2200	72	83
73432	90	111
40112	115	110
23385	77	57
11625	50	75
34823	15	13
23868	147	129
31927	77	78
31951	122	104
75305	67	70
82777	182	178
40727	42	44
84979	50	34
84984	25	26
[redacted]		

n =	22	22
mean =	75.7	75.3
s.d. =	43.30	40.35

Outlier not included in calculations.

Sample Stability

Mayo requests that samples for 25-OH Vitamin D and 1,25-OH Vitamin D should be protected from light The INCSTAR kit insert did not mention any need to protect from light.

Blood was drawn into red top tubes, allowed to clot in the dark for 30 minutes, centrifuged and aliquoted into 12 by 75 mm test tubes. One set of aliquots was stored in the dark and another set was stored on the window sill. Both sets were kept at ambient temperature. A tube was removed and frozen, one from each set, at 0, 1, 2, 4, 6 and 24 hours. All tubes were stored at -70°C. The samples were thawed and assayed together in one run.

Results: Units = nmol/L

Time	Dark	Light	
0 hr	28	28	(mean of 4 results)
1 hr	22	32	
2 hr	24	27	
4 hr	22	35	
6 hr	23	32	
24 hr	31	34	(mean of 2 results)

n =	6	6
mean =	25.00	31.33
s.d. =	3.69	3.20
c.v. =	14.8%	10.2%

There is likely no effect from storing serum in the light at ambient temperature for up to 24 hours. Any variation is likely explained by the imprecision at this low level.

Sensitivity:

Most of the samples sent to our lab for 25-OH Vitamin D analysis are for evaluation of nutritional deficiency.

First Experiment:

Five separate extractions of 0 Standard and 12.5 Standard were run in duplicate tubes in a single assay

0 STD	12.5 STD
CPMS	CPMS
12074.	11000.
12212.	11149.
12545.	10578.
12358.	11196.
12945.	10976.
12461.	11299.
12149.	11445.
12225.	11267.
12489.	11297.

n =	9	9	
mean =	12384.8	11134.4	
s.d =	265.76	256.07	

±3s.d. =	11591 - 13180	10366-11902	(overlap)
±2s.d. =	11853 - 12917	10623 - 11647	(no overlap)

It appears that the assay is barely sensitive to 12.5 nmol/L. Manufacturers published data indicates sensitivity to 6.99 nmol/L at 3 s.d.

Second Experiment:

The extraction procedure was modified in an attempt to improve sensitivity for specimens with low levels of 25-OH Vitamin D. Both increased amounts of specimen and extract were evaluated.

Routine Extraction:	50 µl sample to 500 µl acetonitrile;	25 µl extract to assay
Increased Sample:	100 µl sample to 500 µl acetonitrile	25 µl extract to assay
Increased Extract:	50 µl sample to 500 µl acetonitrile	50 µl extract to assay

Three specimens were assayed on two separate occasions.

Sensitivity, continued

Results:

nmol/L

First Extraction	Routine	Increased Sample	Increased Extract
Sample 1	54	107	180
Sample 2	11	25	67
Sample 3	6	18	49

nmol/L

Second Extraction	Routine	Increased Sample	Increased Extract
Sample 1	59	94	209
Sample 2	6	17	60
Sample 3	7	15	54

Extracting 100 µl of sample instead of 50 µl into the 500 µl of acetonitrile works very well. There was no difficulty in pipetting off the 25 µl aliquots. When the volume of extract in the assay tubes was increased to 50 µl from 25 µl, the results were considerably higher than expected.

Effect of Acetonitrile Volume in Assay Tubes

Various volumes of acetonitrile with no extracted Vitamin D were assayed to evaluate potential "blank" effects.

	Apparent 25-OH-D
	nmol/L
25 µl Acetonitrile	5
25 µl Acetonitrile	6
50 µl Acetonitrile	37
75 µl Acetonitrile	66

The volume of acetonitrile added to the assay tubes is critical. Increased amounts of acetonitrile appear to result in "non-specific" assay interference. An acetonitrile blank should be run in the assay to monitor potential solvent interference.

Reference Range Study:

Mayo Clinic Reference Range

Winter (total): 35 - 105 nmol/L
Summer (total) 37 - 200 nmol/L

INCSTAR Stated Reference Range

October (Minn., USA): 25 - 104 nmol/L

Our Results

59 lab staff sera drawn in July, 1995 were analysed. Two individuals had levels lower than the Mayo reference range lower limit (27 & 31nmol/L). These two individuals were not milk drinkers nor did they spend time in the sun. No one had values higher than Mayo's summer reference range.

61 lab staff sera were collected in January 1996 to check the winter reference range. 25 samples have been analysed so far No sample was lower than the Mayo Clinic range. 6 individuals had values higher than the Mayo winter range (106 - 117 nmol/L).

		nmol/L	nmol/L	nmol/L
n = 59	Summer	mean = 84.5	s.d. = 34.32	2sd range: 16 - 154
n = 25	Winter	mean = 82.88	s.d. = 22.4	2sd range: 38 - 128

Complete set of reference data will be filed separately upon completion of the analysis.

Appendix 5: Laboratory Correlation Test Results for Vitamin D Analysis

R & D Summary: IncStar Vitamin D Assay Small Correlation with Mayo.

Purpose:

A study to determine the nutritional status of Vitamin D in pregnant women on three reservations in northern Manitoba showed a large proportion of deficiences. We were requested to send a few samples to Mayo for confirmation.

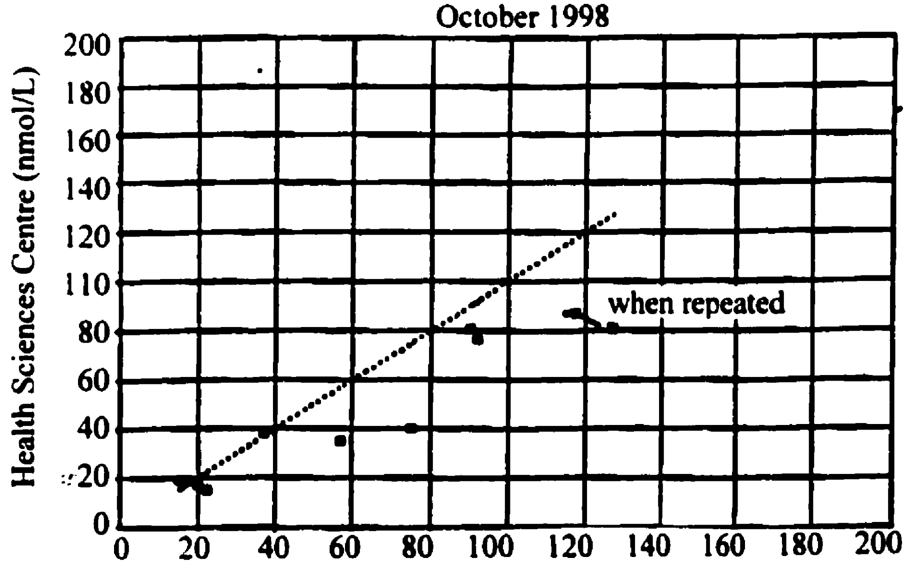
Results:

4 samples from the above study and 2 other samples where volume allowed were sent to Mayo.

Sample Number	Mayo (nmol/L)	Health Sciences (nmol/L)
1	37	38
2	20	17
3	22	15
4	15	19
5	57	35
6	75	40
7	92	77
8	90	81
9	127, 115	81, 87

Shaded samples (1,2,3 & 6) are study patients. Samples No 7, 8 & 9 are lab staff.
#6 When repeated in duplicate at HSC gave 43 and 49 nmol/L. There was insufficient sample to repeat at Mayo.
#9 when repeated by both methods showed slightly better correlation.

Vitamin D Correlation HSC vs. Mayo
October 1998



Appendix 6: Questions for Key Informants in Garden Hill

What is rickets?

When did you first see rickets?

Why do you think rickets happens?

Why do you think there is so much now?

Have you seen Baby-bottle Tooth Decay?

How has people's dress changed?

What are the best foods (most choice)?

How does the cost of groceries affect what you eat?

What would you like to eat more of?

How do you feel about trying new foods?

Do you drink milk?

Do you take vitamins?

When milk became available, what form was it, tins or powder?

How did you use animals for food?

Why is the diet today like it is?

What foods were important to pregnant ladies long ago?

What do you think were the sources of calcium in the old days?

Appendix 7: Information for Participants, Informed Consent Form and Interview Questionnaire

RICKETS STUDY

WHAT IS RICKETS? When mothers don't get enough vitamin D during pregnancy, their children can get rickets. Rickets causes growing children to have seizures, crooked bones, and weak teeth.

WHY DO THIS STUDY? Rickets is common in the Island Lake area but not in Norway House. We are working with people from Garden Hill as a Rickets Committee to compare Island Lake and Norway House. We need to know how many children have rickets and how many pregnant women have low levels of vitamin D in their blood. We also need answers to questions about why the numbers are different. For the next few months, until 35 women from each area have agreed, all pregnant women from Garden Hill, St. Theresa Point, and Norway House will be asked to take part in this study. There are too few pregnancies each year in Wasagamack and Red Sucker Lake to include them in the study but the results will be shared with them. Chief and Council support this study to help to plan rickets prevention.

BLOOD SAMPLES: We would like to collect blood from your veins once at the beginning of your pregnancy. If we can take it at the same time as blood is collected for your regular prenatal tests, both samples can be taken with the same needle. The needle puncture should be painful for only a second. The blood samples will be tested for vitamin D (25-hydroxyvitamin D), calcium, phosphate, and alkaline phosphatase levels, and screened for genetic markers of two vitamin D receptors: Vitamin D Receptor and D Binding Protein.

INTERVIEW QUESTIONS: We would like to ask you about things that might be important in causing rickets. The questions are about food, vitamins, health and sun exposure. The Rickets Committee chose the questions and a local person working on this study will ask for your answers.

RIGHT TO REFUSE: If you do not want us to take blood samples you have the right to refuse and your medical care will not be affected by your decision. You can change your mind or withdraw from the study at any time. You don't have to answer any questions you don't want to.

BENEFITS OF STUDY: The study will be of value to the community and to the health of future children. Also, if your blood levels are not normal, your nurse or doctor will be told and will be able to help raise your levels by offering you vitamins and advice on which foods you might want to eat more often.

CONFIDENTIALITY: All information will remain confidential and no names of individuals will ever be released in reports or publications.

QUESTIONS: The person in your community who will do the interview is XXX. If you have any questions please call XXX at [local phone number] or call the University of Manitoba at 1-800-432-1960 and ask for 789-3473 for Pam Smith or 789-3467 for Dr. Michael Moffatt in the Department of Community Health Sciences.

INFORMED CONSENT TO PARTICIPATE IN RICKETS STUDY

I understand that I am being asked to take part in a study about vitamin D deficiency and rickets.

The interviewer will ask me questions about risks for low vitamin D and rickets. The interview will last about one hour. My blood sample will be tested for levels of vitamin D (25-hydroxyvitamin D), calcium, phosphate, and alkaline phosphatase. My blood will also be screened for the genetic markers of two vitamin D receptors: Vitamin D Receptor and D Binding Protein.

I have been given an oral and written explanation of the study and have had a chance to ask questions. I understand that I do not have to take part in this study and that my medical care will not be affected by this decision. I can withdraw at any time, and do not have to answer any questions I do not want to.

PERMISSION FOR INTERVIEW:

My signature below indicates that I understand and agree to be interviewed about risks for low vitamin D and rickets.

I, (print name) ______________________, agree to be interviewed about risks for low vitamin D and rickets.

Signature of Participant:__________________________ Date:_______________

Signature of Witness:____________________________ Date:_______________

Signature of Investigator__________________________Date:_______________

PERMISSION TO TAKE AND TEST BLOOD:

I, (print name) _____________________, give my permission to have a blood sample taken from my veins to be tested for vitamin D (25-hydroxyvitamin D), calcium, phosphate, and alkaline phosphatase levels, as well as genetic markers of two vitamin D receptors: Vitamin D Receptor and D Binding Protein.

Signature of Participant:_________________________ Date:_______________

Signature of Witness:___________________________ Date:_______________

Signature of Investigator:________________________ Date:_______________

RICKETS STUDY QUESTIONNAIRE Interview Date ___________(mm/dd/yy)

Interviewer___________________________ Community _____________(GH,ST,NH)

Signed Consent Form: ☐ Yes (where_______) Blood Taken: ☐ Yes (date__________)

By whom__________________

A) BACKGROUND

Last name _________________ First name _______________ Treaty #_________

MHSC #____________Date of Birth__________ (mm/dd/yy)

Age ___ Number of Children _____ Number of People in Household _____ Grade _____

Sources of Family Income (check all that apply):

☐ Assistance ☐ part-time job #___ ☐ full-time job #___ ☐ Other_______________

When did you know you were pregnant? __________ Expected Date of Birth __________

Have you ever heard of rickets? ☐ Yes ☐ No ☐ Don't know

If yes, why do you think rickets happens? ______________________________

____

Have any of your children had rickets? ☐ Yes (#___) ☐ No ☐ Don't know

B) SUMMER SUN EXPOSURE

How do you feel about spending time in the sun in summer? _______________________

____

How often do you spend time outdoors in the summer?

☐ Daily ☐ Most days ☐ 1-2 times per week ☐ Rarely ☐ Never

On days you are outdoors, how long are you outside?

☐ 4+ hours ☐ 1-4 hours ☐ 15 min.-1 hour ☐ less than 15 min.

Do you usually avoid the sun and stay in the shade? ☐ Yes ☐ No

Is your skin troubled by sunlight? ☐ Yes ☐ No

How often do you wear a hat?

☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

Rickets Study-Page 1 of 8

How often do you wear short sleeves?

❑ Always ❑ Often ❑ Sometimes ❑ Rarely ❑ Never

How often do you wear short pants/skirts?

❑ Always ❑ Often ❑ Sometimes ❑ Rarely ❑ Never

How often do you wear sunscreen?

❑ Always ❑ Often ❑ Sometimes ❑ Rarely ❑ Never

How often do you use bug spray?

❑ Always ❑ Often ❑ Sometimes ❑ Rarely ❑ Never

In summer, how often do you take part in these outdoor activities:

Gardening or yard work?	❑ Often	❑ Sometimes	❑ Rarely	❑ Never
playing with children?	❑ Often	❑ Sometimes	❑ Rarely	❑ Never
walking?	❑ Often	❑ Sometimes	❑ Rarely	❑ Never
camping?	❑ Often	❑ Sometimes	❑ Rarely	❑ Never
fishing?	❑ Often	❑ Sometimes	❑ Rarely	❑ Never
swimming?	❑ Often	❑ Sometimes	❑ Rarely	❑ Never
boating?	❑ Often	❑ Sometimes	❑ Rarely	❑ Never
berry picking?	❑ Often	❑ Sometimes	❑ Rarely	❑ Never
picnics or visiting	❑ Often	❑ Sometimes	❑ Rarely	❑ Never

other activities? (festivals? #) ______________________________

If you thought that being in the sun more would be good for your health, would you try to spend more time in the sun? ❑ Yes ❑ No ❑ Don't know

When your babies (less than 1 year of age) are outside in the summer, how much of their bodies are exposed to the sun: ❑ none ❑ face only ❑ hands only ❑hands & face ❑ more

C) VITAMIN USE

How do you feel about vitamin pills? ______________________________

____

What do you think vitamin pills <u>do</u> when you take them? ______________________________

____

Do you feel that vitamin pills are necessary? ❑ Yes ❑ No ❑ Don't know

Do you feel that vitamin pills are not natural? ❑ Yes ❑ No ❑ Don't know

How often do you take vitamins?

❑ Most days ❑ Often ❑ Rarely ❑ Only when pregnant ❑ Never

Why? ____________________

If you take vitamins only when pregnant, how often do you take them?:

❑ Always ❑ Most days ❑ Often ❑ Rarely ❑ Never

If you take vitamins, do they include minerals? ❑ Yes ❑ No ❑ Don't know

Do you take calcium supplements? ❑ Yes ❑ No ❑ Don't know

Have health professionals encouraged you to take vitamins? ❑ Yes ❑ No

If yes, what did you think of this advice? ____________________

____

Did you take vitamins? ❑ Yes ❑ No ❑ Don't know

Why (or why not)? ____________________

____

How would you feel about taking a large dose of vitamin D once a year? ____________________

____

Would you take the large dose once a year? ❑ Yes ❑ No ❑ Don't know

D) DIET

How have you changed your diet since you learned you were pregnant? ____________________

____

What do you think are the main sources of calcium in your diet? ____________________

____

How do you feel about milk? ____________________

____

Do you think milk is good for adults? ❑ Yes ❑ No ❑ Don't know

Do you use:

- milk or carnation milk in tea or coffee? ❑ Often ❑ Sometimes ❑ Never
- coffee whitener in tea or coffee? ❑ Often ❑ Sometimes ❑ Never
- milk on cereal? ❑ Often ❑ Sometimes ❑ Never
- powdered milk? ❑ Often ❑ Sometimes ❑ Never
- milk in cooking (soup or macaroni)? ❑ Often ❑ Sometimes ❑ Never

How often do you drink milk when not pregnant? ❑ Often ❑ Sometimes ❑ Never

If you drink milk when not pregnant, on average, how many cups?

❑ 3 or 4 per day ❑ 1 or 2 per day ❑ 1 every few days ❑ 1 per week ❑ less

How often do you drink milk when you are pregnant? ❑ Often ❑ Sometimes ❑ Never

If you drink milk when you are pregnant, on average, how many cups?

❑ 3 or 4 per day ❑ 1 or 2 per day ❑ 1 every few days ❑ 1 per week ❑ less

What kind of milk do you drink? ______________________________

Do you feel sick after drinking milk? ❑ Always ❑ Often ❑ Sometimes ❑ Never

What symptoms do you get? ______________________________

How often do you usually eat:

Cheese?	❑ Often ❑ Sometimes ❑ Never
Ice cream?	❑ Often ❑ Sometimes ❑ Never
Yogurt?	❑ Often ❑ Sometimes ❑ Never
Hot chocolate?	❑ Often ❑ Sometimes ❑ Never
Broccoli?	❑ Often ❑ Sometimes ❑ Never
Other green vegetables?	❑ Often ❑ Sometimes ❑ Never
Turnip?	❑ Often ❑ Sometimes ❑ Never
Sardines?	❑ Often ❑ Sometimes ❑ Never
Fish soup?	❑ Often ❑ Sometimes ❑ Never
Meat soup (made from bones)?	❑ Often ❑ Sometimes ❑ Never
Organ meat from animals?	❑ Often ❑ Sometimes ❑ Never

Which of the following foods would you like to eat more of:

Milk?	❑ Yes ❑ No ❑ Don't know
Cheese?	❑ Yes ❑ No ❑ Don't know
Ice cream?	❑ Yes ❑ No ❑ Don't know
Yogurt?	❑ Yes ❑ No ❑ Don't know
Green vegetables?	❑ Yes ❑ No ❑ Don't know
Fish?	❑ Yes ❑ No ❑ Don't know
Fish soup or meat soup?	❑ Yes ❑ No ❑ Don't know

Why do you not eat more of these foods? ______________________________

____

Would you eat more of these foods if they were less expensive?

❑ Yes ❑ No ❑ Don't know

Have health professionals encouraged you to drink milk? ❑ Yes ❑ No ❑ Don't know

If yes, what did you think of this advice? ______________________________

____

Did you drink more milk? ❑ Yes ❑ No ❑ Don't know

Why or why not? ____

____

On most days, do you eat:

Pasta/Bread?	❑ Yes	❑ No	❑ Don't know
Meat/fish?	❑ Yes	❑ No	❑ Don't know
Fruit?	❑ Yes	❑ No	❑ Don't know
Vegetable?	❑ Yes	❑ No	❑ Don't know

Other? ____

How many cups of milk did you drink this week?

❑ 3 or 4 per day ❑ 1 or 2 per day ❑ 1 every few days ❑ 1 per week ❑ none

How many times did you eat cheese or other dairy products this week?

❑ 3 or 4 per day ❑ 1 or 2 per day ❑ 1 every few days ❑ 1 per week ❑ none

Where do you get most of your food? ______________________________

____

Where do you get the rest your food? (wild?) ______________________________

____

Do you, or someone in your family:

Hunt/trap?	❑ Yes ❑ No ❑ Don't know
Fish?	❑ Yes ❑ No ❑ Don't know
Garden	❑ Yes ❑ No ❑ Don't know
Gather (berries or other wild food)	❑ Yes ❑ No ❑ Don't know

How would you feel about having vitamin D or calcium put in a food you eat, and you couldn't tell that it was there, except for on the package label? ______________________

____

Would you continue to eat this food if you eat it now? ❑ Yes ❑ No ❑ Don't know

Would you try to eat more of that food if you didn't normally eat much of it?

❑ Yes ❑ No ❑ Don't know

What foods do you make that could have powdered milk added to them? ______________

____

E) INFANT DIET

Do you breast feed your babies? ❑ Yes ❑ No ❑ Some

If yes, for how long did you breast feed your last baby? ____________________

Did you feed your last baby:

Evaporated milk?	❑ Yes ❑ No ❑ Don't know
Whole milk?	❑ Yes ❑ No ❑ Don't know
2%, 1% or skim milk?	❑ Yes ❑ No ❑ Don't know
Infant formula (baby milk, not pablum)?	❑ Yes ❑ No ❑ Don't know

How many months old was your last baby when you started to give:

Formula or milk (other than breast milk)?	❑ 0,1,2	❑ 3,4,5	❑ 6 or more
Food other than milk?	❑ 0,1,2	❑ 3,4,5	❑ 6 or more

What were your last baby's first foods? ______________________________

____

What foods are especially good for pregnant women? ______________________________

____

Did you eat these foods during your last pregnancy? ☐ Yes ☐ No ☐ Don't know

Did you give vitamin drops to your last baby? ☐ Yes ☐ No ☐ Don't know

Why or why not? ______________________________________

____

If yes, how often did you give vitamin drops to your last baby?

☐ Always ☐ Most Days ☐ Often ☐ Rarely ☐ Never

Do you give milk to your children over 1 year of age? ☐ Yes ☐ No ☐ Don't know

How many of your children have gone to Winnipeg to have dental work?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ more (give #) ______

How many of your children have had general anaesthetic for dental surgery?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ more (give #) ______

F) HEALTH

Do you consider yourself healthy? ☐ Yes ☐ No ☐ Don't know

Do you have bone pain? ☐ Yes ☐ No ☐ Don't know

Do you have weak muscles in your arms or legs? ☐ Yes ☐ No ☐ Don't know

Do you have numbness/tingling of hands/ feet/mouth? ☐ Yes ☐ No ☐ Don't know

Do you have trouble getting up to stand? ☐ Yes ☐ No ☐ Don't know

Do you walk with a limp? ☐ Yes ☐ No ☐ Don't know

Do, or did, you have a dislocated hip? ☐ Yes ☐ No ☐ Don't know

Do you have diabetes? ☐ Yes ☐ No ☐ Don't know

When did you learn that you have diabetes? ______________________________

If you found out that you were vitamin D deficient what would you do? ______________

____

Would you be willing to change your diet and lifestyle in ways that would increase your vitamin D and calcium levels?

❑ Yes ❑ No ❑ Don't know

Which of the following changes would you be willing to make:

Eat more dairy products? ❑ Yes ❑ No ❑ Don't know

Take vitamins regularly? ❑ Yes ❑ No ❑ Don't know

Take a high dose vitamin supplement once a year?

❑ Yes ❑ No ❑ Don't know

Spend more time in the sun? ❑ Yes ❑ No ❑ Don't know

Support efforts to have vitamin D and calcium added to common foods?

❑ Yes ❑ No ❑ Don't know

Support efforts to make dairy products more affordable?

❑ Yes ❑ No ❑ Don't know

Try to find non-dairy, diet sources of vitamin D and calcium?

❑ Yes ❑ No ❑ Don't know

F) INVENTORY: type & amount in fridge & cupboard

Can I see the kinds of milk you have today? ❑ Yes ❑ No

(If yes, please describe): ____

____

Can I see your cheese? ❑ Yes ❑ No

(If yes: please describe): ____

____

Can I see your vitamin pills and drops? ❑ Yes ❑ No

(If yes, please describe, expiry dates?): ____________________________

____

Appendix 8: Blood Results

Vitamin D Deficiency		Garden Hill	St. Theresa Point	Norway House	Total
low:	Count	27	32	29	88
<35 nmol/L	Community %	84.4%	91.4%	78.4%	84.6%
normal:	Count	5	3	8	16
35-200 nmol/L	Community %	15.6%	8.6%	21.6%	15.4%
Total	Count	32	35	37	104
	Community %	100.0%	100.0%	100.0%	100.0%

Extreme Vitamin D Deficiency		Garden Hill	St. Theresa Point	Norway House	Total
<15 nmol/L	Count	8	6	4	18
	Community %	25.0%	17.1%	10.8%	17.3%
15-34 nmol/L	Count	19	26	25	70
	Community %	59.4%	74.3%	67.6%	67.3%
>35 nmol/L	Count	5	3	8	16
	Community %	15.6%	8.6%	21.6%	15.4%
Total	Count	32	35	37	104
	Community %	100.0%	100.0%	100.0%	100.0%

Alkaline Phosphatase Status		Garden Hill	St. Theresa Point	Norway House	Total
normal	Count	29	29	31	89
	Community %	90.6%	82.9%	83.8%	85.6%
high	Count	3	6	6	15
	Community %	9.4%	17.1%	16.2%	14.4%
Total	Count	32	35	37	104
	Community %	100.0%	100.0%	100.0%	100.0%

Calcium Status		Garden Hill	St. Theresa Point	Norway House	Total
low	Count	7	6	3	16
	Community %	21.9%	17.1%	8.1%	15.4%
normal	Count	25	29	34	88
	Community %	78.1%	82.9%	91.9%	84.6%
Total	Count	32	35	37	104
	Community %	100.0%	100.0%	100.0%	100.0%

Phosphate Status		Garden Hill	St. Theresa Point	Norway House	**Total**
low	Count	5	5	3	13
	Community %	15.6%	14.3%	8.1%	12.5%
normal	Count	20	26	32	78
	Community %	62.5%	74.3%	86.5%	75.0%
high	Count	7	4	2	13
	Community %	21.9%	11.4%	5.4%	12.5%
Total	Count	32	35	37	104
	Community %	100.0%	100.0%	100.0%	100.0%

Appendix 9: Responses to Close-Ended Questions by Community

1. Have you ever heard of rickets?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	16	18	25	59
	Community %	66.7%	51.4%	69.4%	62.1%
yes	Count	5	17	10	32
	Community %	20.8%	48.6%	27.8%	33.7%
don't know	Count	3		1	4
	Community %	12.5%		2.8%	4.2%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

2. How often do you spend time outdoors in the summer?

		Garden Hill	St. Theresa Point	Norway House	**Total**
rarely	Count		7	4	11
	Community %		20.0%	11.1%	11.7%
1-2 times/week	Count	7	2	3	12
	Community %	30.4%	5.7%	8.3%	12.8%
most days	Count	14	9	17	40
	Community %	60.9%	25.7%	47.2%	42.6%
daily	Count	2	17	12	31
	Community %	8.7%	48.6%	33.3%	33.0%
Total	Count	23	35	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

3. On days you are outdoors, how long are you outside?

		Garden Hill	St. Theresa Point	Norway House	**Total**
less than 15 minutes	Count	1	1	3	5
	Community %	4.2%	2.9%	8.3%	5.3%
15 minutes to 1 hour	Count	8	18	2	28
	Community %	33.3%	51.4%	5.6%	29.5%
1 to 4 hours	Count	14	15	26	55
	Community %	58.3%	42.9%	72.2%	57.9%
4 or more hours	Count	1	1	5	7
	Community %	4.2%	2.9%	13.9%	7.4%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

4. Do you usually avoid the sun and stay in the shade?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	4	13	17	34
	Community %	16.7%	37.1%	47.2%	35.8%
yes	Count	20	22	19	61
	Community %	83.3%	62.9%	52.8%	64.2%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

5. Is your skin troubled by sunlight?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	19	31	30	80
	Community %	82.6%	91.2%	83.3%	86.0%
yes	Count	4	3	6	13
	Community %	17.4%	8.8%	16.7%	14.0%
Total	Count	23	34	36	93
	Community %	100.0%	100.0%	100.0%	100.0%

6. How often do you wear a hat?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	18	24	13	55
	Community %	75.0%	68.6%	36.1%	57.9%
rarely	Count	2	5	10	17
	Community %	8.3%	14.3%	27.8%	17.9%
sometimes	Count	2	4	10	16
	Community %	8.3%	11.4%	27.8%	16.8%
often	Count	2	1	3	6
	Community %	8.3%	2.9%	8.3%	6.3%
always	Count		1		1
	Community %		2.9%		1.1%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

7. How often do you wear short sleeves?

		Garden Hill	St. Theresa Point	Norway House	**Total**
rarely	Count	1		1	2
	Community %	4.2%		2.8%	2.1%
sometimes	Count	5	2	7	14
	Community %	20.8%	5.7%	19.4%	14.7%
often	Count	11	10	6	27
	Community %	45.8%	28.6%	16.7%	28.4%
always	Count	7	23	22	52
	Community %	29.2%	65.7%	61.1%	54.7%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

8. How often do you wear short pants/skirts?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	6	2	5	13
	Community %	25.0%	5.7%	13.9%	13.7%
rarely	Count	8	2	4	14
	Community %	33.3%	5.7%	11.1%	14.7%
sometimes	Count	9	15	13	34
	Community %	37.5%	42.9%	36.1%	38.9%
often	Count	1	12	6	19
	Community %	4.2%	34.3%	16.7%	20.0%
always	Count		4	8	12
	Community %		11.4%	22.2%	12.6%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

9. How often do you wear sunscreen?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	20	24	12	56
	Community %	83.3%	68.6%	36.4%	60.9%
rarely	Count	2	6	7	15
	Community %	8.3%	17.1%	21.2%	16.3%
sometimes	Count		3	7	10
	Community %		8.6%	21.2%	10.9%
often	Count	2	1	3	6
	Community %	8.3%	2.9%	9.1%	6.5%
always	Count		1	4	5
	Community %		2.9%	12.1%	5.4%
Total	Count	24	35	33	92
	Community %	100.0%	100.0%	100.0%	100.0%

10. How often do you use bug spray?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	9	9	8	26
	Community %	37.5%	25.7%	22.2%	27.4%
rarely	Count	4	9	6	19
	Community %	16.7%	25.7%	16.7%	20.0%
sometimes	Count	9	15	13	37
	Community %	37.5%	42.9%	36.1%	38.9%
often	Count	2	1	7	10
	Community %	8.3%	2.9%	19.4%	10.5%
always	Count		1	2	3
	Community %		2.9%	5.6%	3.2%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

11. In summer, how often do you take part in these outdoor activities:
a) gardening or yard work?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	21	12	8	41
	Community %	87.5%	34.3%	22.9%	43.6%
rarely	Count	1	3	6	10
	Community %	4.2%	8.6%	17.1%	10.6%
sometimes	Count	2	19	18	39
	Community %	8.3%	54.3%	51.4%	41.5%
often	Count		1	3	4
	Community %		2.9%	8.6%	4.3%
Total	Count	24	35	35	94
	Community %	100.0%	100.0%	100.0%	100.0%

b) playing with children?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	4			4
	Community %	16.7%			4.2%
rarely	Count		1	1	2
	Community %		2.9%	2.8%	2.1%
sometimes	Count	13	21	16	50
	Community %	54.2%	60.0%	44.4%	52.6%
often	Count	7	13	19	39
	Community %	29.2%	37.1%	52.8%	41.1%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

c) walking?

		Garden Hill	St. Theresa Point	Norway House	**Total**
rarely	Count	3	3	4	10
	Community %	12.5%	8.6%	11.1%	10.5%
sometimes	Count	19	15	20	54
	Community %	79.2%	42.9%	55.6%	56.8%
often	Count	2	17	12	31
	Community %	8.3%	48.6%	33.3%	32.6%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

d) camping?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	17	18	14	49
	Community %	73.9%	51.4%	40.0%	52.7%
rarely	Count	1	9	11	21
	Community %	4.3%	25.7%	31.4%	22.6%
sometimes	Count	3	8	8	19
	Community %	13.0%	22.9%	22.9%	20.4%
often	Count	2		2	4
	Community %	8.7%		5.7%	4.3%
Total	Count	23	35	35	93
	Community %	100.0%	100.0%	100.0%	100.0%

e) fishing?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	8	21	4	33
	Community %	33.3%	60.0%	11.1%	34.7%
rarely	Count	7	7	15	29
	Community %	29.2%	20.0%	41.7%	30.5%
sometimes	Count	7	6	14	27
	Community %	29.2%	17.1%	38.9%	28.4%
often	Count	2	1	3	6
	Community %	8.3%	2.9%	8.3%	6.3%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

f) swimming?

		Garden Hill	St. Theresa Point	Norway House	Total
never	Count	5	8	5	18
	Community %	20.8%	22.9%	13.9%	18.9%
rarely	Count	1	6	11	18
	Community %	4.2%	17.1%	30.6%	18.9%
sometimes	Count	17	15	12	44
	Community %	70.8%	42.9%	33.3%	46.3%
often	Count	1	6	8	15
	Community %	4.2%	17.1%	22.2%	15.8%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

g) boating?

		Garden Hill	St. Theresa Point	Norway House	Total
never	Count	7	4	3	14
	Community %	30.4%	11.8%	8.3%	15.1%
rarely	Count	5	3	7	15
	Community %	21.7%	8.8%	19.4%	16.1%
sometimes	Count	10	20	22	52
	Community %	43.5%	58.8%	61.1%	55.9%
often	Count	1	7	4	12
	Community %	4.3%	20.6%	11.1%	12.9%
Total	Count	23	34	36	93
	Community %	100.0%	100.0%	100.0%	100.0%

h) berry picking?

		Garden Hill	St. Theresa Point	Norway House	Total
never	Count	11	13	4	28
	Community %	47.8%	37.1%	11.4%	30.1%
rarely	Count	3	8	11	22
	Community %	13.0%	22.9%	31.4%	23.7%
sometimes	Count	8	9	18	35
	Community %	34.8%	25.7%	51.4%	37.6%
often	Count	1	5	2	8
	Community %	4.3%	14.3%	5.7%	8.6%
Total	Count	23	35	35	93
	Community %	100.0%	100.0%	100.0%	100.0%

i) picnics or visiting?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	10	6		16
	Community %	43.5%	17.1%		17.2%
rarely	Count	6	4	3	13
	Community %	26.1%	11.4%	8.6%	14.0%
sometimes	Count	6	18	16	40
	Community %	26.1%	51.4%	45.7%	43.0%
often	Count	1	7	16	24
	Community %	4.3%	20.0%	45.7%	25.8%
Total	Count	23	35	35	93
	Community %	100.0%	100.0%	100.0%	100.0%

j) other activities (festivals/sports)?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count		2		2
	Community %		9.5%		3.8%
yes	Count	1	19	31	51
	Community %	100.0%	90.5%	100.0%	96.2%
Total	Count	1	21	31	53
	Community %	100.0%	100.0%	100.0%	100.0%

12. If you thought that being in the sun more would be good for your health, would you try to spend more time in the sun?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count		4	5	9
	Community %		11.4%	14.3%	9.6%
yes	Count	16	26	24	66
	Community %	66.7%	74.3%	68.6%	70.2%
don't know	Count	8	5	6	19
	Community %	33.3%	14.3%	17.1%	20.2%
Total	Count	24	35	35	94
	Community %	100.0%	100.0%	100.0%	100.0%

13. When your babies (less than 1 year of age) are outside in the summer, how much of their bodies are exposed to the sun?

		Garden Hill	St. Theresa Point	Norway House	**Total**
none	Count	1	1	2	4
	Community %	5.6%	4.5%	7.7%	6.1%
face only	Count		1	1	2
	Community %		4.5%	3.8%	3.0%
hands only	Count			3	3
	Community %			11.5%	4.5%
hands & face	Count	14	15	17	46
	Community %	77.8%	68.2%	65.4%	69.7%
more than hands & face	Count	3	5	3	11
	Community %	16.7%	22.7%	11.5%	16.7%
Total	Count	18	22	36	66
	Community %	100.0%	100.0%	100.0%	100.0%

14. Do you feel that vitamin pills are necessary?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count		4	3	7
	Community %		11.4%	8.3%	7.4%
yes	Count	7	25	28	60
	Community %	29.2%	71.4%	77.8%	63.2%
don't know	Count	17	6	5	28
	Community %	70.8%	17.1%	13.9%	29.5%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

15. Do you feel that vitamin pills are not natural?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	2	14	15	31
	Community %	8.7%	41.2%	41.7%	33.3%
yes	Count		3	4	7
	Community %		8.8%	11.1%	7.5%
don't know	Count	21	17	17	55
	Community %	91.3%	50.0%	47.2%	59.1%
Total	Count	23	34	36	93
	Community %	100.0%	100.0%	100.0%	100.0%

16. How often do you take vitamins?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	5	4	4	13
	Community %	20.8%	11.4%	11.1%	13.7%
only when pregnant	Count	9	24	21	54
	Community %	37.5%	68.6%	58.3%	56.8%
rarely	Count	5	1	8	14
	Community %	20.8%	2.9%	22.2%	14.7%
often	Count	1	4	1	6
	Community %	4.2%	11.4%	2.8%	6.3%
most days	Count	4	2	2	8
	Community %	16.7%	5.7%	5.6%	8.4%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

17. If you take vitamins only when pregnant, how often do you take them?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	5	4	4	13
	Community %	20.8%	11.8%	11.1%	13.8%
rarely	Count	3	3	3	9
	Community %	12.5%	8.8%	8.3%	9.6%
often	Count	2	3	4	9
	Community %	8.3%	8.8%	11.1%	9.6%
most days	Count	8	10	15	33
	Community %	33.3%	29.4%	41.7%	35.1%
always	Count	6	14	10	30
	Community %	25.0%	41.2%	27.8%	31.9%
Total	Count	24	34	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

18. If you take vitamins, do they include minerals?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count		6	1	7
	Community %		19.4%	3.1%	8.6%
yes	Count	2	14	8	24
	Community %	11.1%	45.2%	25.0%	29.6%
don't know	Count	16	11	23	50
	Community %	88.9%	35.5%	71.9%	61.7%
Total	Count	18	31	32	81
	Community %	100.0%	100.0%	100.0%	100.0%

19. Do you take calcium supplements?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	14	26	26	66
	Community %	58.3%	74.3%	78.8%	71.7%
yes	Count	1	2	3	6
	Community %	4.2%	5.7%	9.1%	6.5%
don't know	Count	9	7	4	20
	Community %	37.5%	20.0%	12.1%	21.7%
Total	Count	24	35	33	92
	Community %	100.0%	100.0%	100.0%	100.0%

20. Have health professionals encouraged you to take vitamins?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	7	3	12	22
	Community %	30.4%	8.8%	35.3%	24.2%
yes	Count	16	31	22	69
	Community %	69.6%	91.2%	64.7%	75.8%
Total	Count	23	34	34	91
	Community %	100.0%	100.0%	100.0%	100.0%

21. Did you take vitamins after encouragement?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	11	7	9	27
	Community %	47.8%	21.9%	30.0%	31.8%
yes	Count	12	24	19	55
	Community %	52.2%	75.0%	63.3%	64.7%
don't know	Count		1	2	3
	Community %		3.1%	6.7%	3.5%
Total	Count	23	32	30	85
	Community %	100.0%	100.0%	100.0%	100.0%

22. Would you take a large dose of vitamin D once a year?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	1	8	2	11
	Community %	4.3%	22.9%	5.7%	11.8%
yes	Count	5	17	29	51
	Community %	21.7%	48.6%	82.9%	54.8%
don't know	Count	17	10	4	31
	Community %	73.9%	28.6%	11.4%	33.3%
Total	Count	23	35	35	93
	Community %	100.0%	100.0%	100.0%	100.0%

23. Do you think milk is good for adults?

		Garden Hill	St. Theresa Point	Norway House	**Total**
yes	Count	15	32	35	82
	Community %	65.2%	91.4%	97.2%	87.2%
don't know	Count	8	3	1	12
	Community %	34.8%	8.6%	2.8%	12.8%
Total	Count	23	35	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

24. Do you:

a) use milk or carnation milk in tea or coffee?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	3	22	9	34
	Community %	12.5%	62.9%	25.0%	35.8%
sometimes	Count	6	9	8	23
	Community %	25.0%	25.7%	22.2%	24.2%
often	Count	15	4	19	38
	Community %	62.5%	11.4%	52.8%	40.0%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

b) use coffee whitener in tea or coffee?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	2	14	18	34
	Community %	8.3%	40.0%	51.4%	36.2%
sometimes	Count	4	15	13	32
	Community %	16.7%	42.9%	37.1%	34.0%
often	Count	18	6	4	28
	Community %	75.0%	17.1%	11.4%	29.8%
Total	Count	24	35	35	94
	Community %	100.0%	100.0%	100.0%	100.0%

c) use milk on cereal?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	1		1	2
	Community %	4.2%		2.8%	2.1%
sometimes	Count	8	12	6	26
	Community %	33.3%	34.3%	16.7%	27.4%
often	Count	15	23	29	67
	Community %	62.5%	65.7%	80.6%	70.5%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

d) use powdered milk?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	17	29	31	77
	Community %	70.8%	85.3%	88.6%	82.8%
sometimes	Count	7	5	4	16
	Community %	29.2%	14.7%	11.4%	17.2%
Total	Count	24	34	35	93
	Community %	100.0%	100.0%	100.0%	100.0%

e) use milk in cooking (soup or macaroni)?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	19	21	5	45
	Community %	79.2%	60.0%	13.9%	47.4%
sometimes	Count	5	10	13	28
	Community %	20.8%	28.6%	36.1%	29.5%
often	Count		4	18	22
	Community %		11.4%	50.0%	23.2%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

25. How often do you drink milk when not pregnant?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	1	8	4	13
	Community %	4.2%	22.9%	11.1%	13.7%
sometimes	Count	15	18	23	56
	Community %	62.5%	51.4%	63.9%	58.9%
often	Count	8	9	9	26
	Community %	33.3%	25.7%	25.0%	27.4%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

26. If you drink milk when not pregnant, on average how many cups?

		Garden Hill	St. Theresa Point	Norway House	**Total**
less than 1 cup/week	Count		5	3	8
	Community %		18.5%	9.1%	9.6%
1 cup/week	Count	2	4	3	9
	Community %	8.7%	14.8%	9.1%	10.8%
1 cup every few days	Count	3	3	4	10
	Community %	13.0%	11.1%	12.1%	12.0%
1 or 2 cups/day	Count	12	11	17	40
	Community %	52.2%	40.7%	51.5%	48.2%
3 or 4 cups/day	Count	6	4	6	16
	Community %	26.1%	14.8%	18.2%	19.3%
Total	Count	23	27	33	83
	Community %	100.0%	100.0%	100.0%	100.0%

27. How often do you drink milk when you are pregnant?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	1	4		5
	Community %	4.2%	12.1%		5.4%
sometimes	Count	14	21	14	49
	Community %	58.3%	63.6%	38.9%	52.7%
often	Count	9	8	22	39
	Community %	37.5%	24.2%	61.1%	41.9%
Total	Count	24	33	36	93
	Community %	100.0%	100.0%	100.0%	100.0%

28. If you drink milk when you are pregnant, on average how many cups?

		Garden Hill	St. Theresa Point	Norway House	**Total**
less than 1 cup/week	Count	1	5	1	7
	Community %	4.3%	16.7%	2.9%	8.0%
1 cup/week	Count	1	1	1	3
	Community %	4.3%	3.3%	2.9%	3.4%
1 cup every few days	Count	3	7	4	14
	Community %	13.0%	23.3%	11.4%	15.9%
1 or 2 cups/day	Count	11	12	12	34
	Community %	47.8%	40.0%	34.3%	39.8%
3 or 4 cups/day	Count	7	5	17	29
	Community %	30.4%	16.7%	48.6%	33.0%
Total	Count	23	30	35	88
	Community %	100.0%	100.0%	100.0%	100.0%

29. What kind of milk do you drink?

		Garden Hill	St. Theresa Point	Norway House	**Total**
none	Count	1	2		3
	Community %	4.2%	5.7%		3.2%
whitener only or with milk	Count	9	1		10
	Community %	37.5%	2.9%		10.5%
liquid milk	Count	14	32	36	82
	Community %	58.3%	91.4%	100.0%	86.3%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

30. Do you feel sick after drinking milk?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	22	25	23	70
	Community %	91.7%	71.4%	63.9%	73.7%
sometimes	Count	2	10	13	25
	Community %	8.3%	28.6%	36.1%	26.3%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

31. How often do you usually eat:
a) cheese?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	1	5	2	8
	Community %	4.2%	14.3%	5.6%	8.4%
sometimes	Count	20	26	21	67
	Community %	83.3%	74.3%	58.3%	70.5%
often	Count	3	4	13	20
	Community %	12.5%	11.4%	36.1%	21.1%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

b) ice cream?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	1	2	4	7
	Community %	4.2%	5.7%	11.1%	7.4%
sometimes	Count	15	24	22	61
	Community %	62.5%	68.6%	61.1%	64.2%
often	Count	8	9	10	27
	Community %	33.3%	25.7%	27.8%	28.4%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

c) yogurt?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	11	17	6	34
	Community %	45.8%	48.6%	16.7%	35.8%
sometimes	Count	9	13	21	43
	Community %	37.5%	37.1%	58.3%	45.3%
often	Count	4	5	9	18
	Community %	16.7%	14.3%	25.0%	18.9%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

d) hot chocolate?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	10	17	13	40
	Community %	41.7%	48.6%	36.1%	42.1%
sometimes	Count	11	18	21	50
	Community %	45.8%	51.4%	58.3%	52.6%
often	Count	3		2	5
	Community %	12.5%		5.6%	5.3%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

e) broccoli?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	22	29	20	71
	Community %	95.7%	82.9%	55.6%	75.5%
sometimes	Count	1	5	10	16
	Community %	4.3%	14.3%	27.8%	17.0%
often	Count		1	6	7
	Community %		2.9%	16.7%	7.4%
Total	Count	23	35	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

f) other green vegetables?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	7	4	2	13
	Community %	29.2%	11.4%	5.6%	13.7%
sometimes	Count	16	21	20	57
	Community %	66.7%	60.0%	55.6%	60.0%
often	Count	1	10	14	25
	Community %	4.2%	28.6%	38.9%	26.3%
Total	Count	24	35	35	95
	Community %	100.0%	100.0%	100.0%	100.0%

g) turnips?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	23	34	23	80
	Community %	100.0%	97.1%	65.7%	86.0%
sometimes	Count		1	9	10
	Community %		2.9%	25.7%	10.8%
often	Count			3	3
	Community %			8.6%	3.2%
Total	Count	23	35	35	93
	Community %	100.0%	100.0%	100.0%	100.0%

h) sardines?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	23	32	34	89
	Community %	95.8%	94.1%	94.4%	94.7%
sometimes	Count	1	2	1	4
	Community %	4.2%	5.9%	2.8%	4.3%
often	Count			1	1
	Community %			2.8%	1.1%
Total	Count	24	34	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

i) fish soup?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	18	22	22	62
	Community %	75.0%	62.9%	61.1%	65.3%
sometimes	Count	6	10	13	29
	Community %	25.0%	28.6%	36.1%	30.5%
often	Count		3	1	4
	Community %		8.6%	2.8%	4.2%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

j) meat soup (made from bones)?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	11		1	12
	Community %	45.8%		2.8%	12.6%
sometimes	Count	13	19	27	59
	Community %	54.2%	54.3%	75.0%	62.1%
often	Count		16	8	24
	Community %		45.7%	22.2%	25.3%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

32. organ meat from animals?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	8	10	19	37
	Community %	33.3%	28.6%	52.8%	38.9%
sometimes	Count	14	16	15	45
	Community %	58.3%	45.7%	41.7%	47.4%
often	Count	2	9	1	12
	Community %	8.3%	25.7%	2.8%	12.6%
don't know	Count		7	1	1
	Community %			2.8%	1.1%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

33. Which of the following foods would you like to eat more of:
a) milk?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	1	3	2	6
	Community %	4.2%	8.6%	5.7%	6.4%
yes	Count	18	29	28	75
	Community %	75.0%	82.9%	80.0%	79.8%
don't know	Count	5	3	5	13
	Community %	20.8%	8.6%	14.3%	13.8%
Total	Count	24	35	35	94
	Community %	100.0%	100.0%	100.0%	100.0%

b) cheese?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	2	3	2	7
	Community %	8.3%	8.6%	5.7%	7.4%
yes	Count	17	31	32	80
	Community %	70.8%	88.6%	91.4%	85.1%
don't know	Count	5	1	1	7
	Community %	20.8%	2.9%	2.9%	7.4%
Total	Count	24	35	35	94
	Community %	100.0%	100.0%	100.0%	100.0%

c) ice cream?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	1	11	10	22
	Community %	4.2%	31.4%	28.6%	23.4%
yes	Count	20	22	22	64
	Community %	83.3%	62.9%	62.9%	68.1%
don't know	Count	3	2	3	8
	Community %	12.5%	5.7%	8.6%	8.5%
Total	Count	24	35	35	94
	Community %	100.0%	100.0%	100.0%	100.0%

d) yogurt?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	4	15	4	23
	Community %	16.7%	42.9%	11.4%	24.5%
yes	Count	16	17	28	61
	Community %	66.7%	48.6%	80.0%	64.9%
don't know	Count	4	3	3	10
	Community %	16.7%	8.6%	8.6%	10.6%
Total	Count	24	35	35	94
	Community %	100.0%	100.0%	100.0%	100.0%

e) green vegetables?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	7	3	2	12
	Community %	29.2%	8.6%	5.7%	12.8%
yes	Count	12	29	31	72
	Community %	50.0%	82.9%	88.6%	76.6%
don't know	Count	5	3	2	10
	Community %	20.8%	8.6%	5.7%	10.6%
Total	Count	24	35	35	94
	Community %	100.0%	100.0%	100.0%	100.0%

f) fish?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	9	5	6	20
	Community %	37.5%	14.3%	16.7%	21.1%
yes	Count	14	27	28	69
	Community %	58.3%	77.1%	77.8%	72.6%
don't know	Count	1	3	2	6
	Community %	4.2%	8.6%	5.6%	6.3%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

g) fish or meat soup?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	8		4	12
	Community %	33.3%		11.4%	12.8%
yes	Count	15	33	27	75
	Community %	62.5%	94.3%	77.1%	79.8%
don't know	Count	1	2	4	7
	Community %	4.2%	5.7%	11.4%	7.4%
Total	Count	24	35	35	94
	Community %	100.0%	100.0%	100.0%	100.0%

34. Would you eat more of these foods if they were less expensive?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	1	1	5	7
	Community %	4.3%	2.9%	14.3%	7.5%
yes	Count	18	29	28	75
	Community %	78.3%	82.9%	80.0%	80.6%
don't know	Count	4	5	2	11
	Community %	17.4%	14.3%	5.7%	11.8%
Total	Count	23	35	35	93
	Community %	100.0%	100.0%	100.0%	100.0%

35. Have health professionals encouraged you to drink milk?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	7	18	8	33
	Community %	29.2%	52.9%	22.9%	35.5%
yes	Count	16	15	26	57
	Community %	66.7%	44.1%	74.3%	61.3%
don't know	Count	1	1	1	3
	Community %	4.2%	2.9%	2.9%	3.2%
Total	Count	24	34	35	93
	Community %	100.0%	100.0%	100.0%	100.0%

36. Did you drink more milk after encouragement?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	11	6	9	26
	Community %	61.1%	37.5%	32.1%	41.9%
yes	Count	7	8	19	34
	Community %	38.9%	50.0%	67.9%	54.8%
don't know	Count		2		2
	Community %		12.5%		3.2%
Total	Count	18	16	28	62
	Community %	100.0%	100.0%	100.0%	100.0%

37. On most days, do you eat:
a) pasta/bread?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	7	2		9
	Community %	30.4%	5.7%		9.6%
yes	Count	16	33	36	85
	Community %	69.6%	94.3%	100.0%	90.4%
Total	Count	23	35	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

b) meat/fish?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	16		3	19
	Community %	69.6%		8.3%	20.4%
yes	Count	7	34	33	74
	Community %	30.4%	100.0%	91.7%	79.6%
Total	Count	23	34	36	93
	Community %	100.0%	100.0%	100.0%	100.0%

c) fruit?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	11	1	1	13
	Community %	45.8%	2.9%	2.8%	13.8%
yes	Count	13	33	35	81
	Community %	54.2%	97.1%	97.2%	86.2%
Total	Count	24	34	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

d) vegetables?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	17	2	4	23
	Community %	81.0%	6.1%	11.1%	25.6%
yes	Count	4	31	32	67
	Community %	19.0%	93.9%	88.9%	74.4%
Total	Count	21	33	36	90
	Community %	100.0%	100.0%	100.0%	100.0%

38. How many cups of milk did you drink this week?

		Garden Hill	St. Theresa Point	Norway House	**Total**
none	Count	2	10	3	15
	Community %	8.3%	29.4%	8.3%	16.0%
1 per week	Count	1	3	2	6
	Community %	4.2%	8.8%	5.6%	6.4%
1 every few days	Count	2	5	2	9
	Community %	8.3%	14.7%	5.6%	9.6%
1 or 2 per day	Count	10	11	13	34
	Community %	41.7%	32.4%	36.1%	36.2%
3 or 4 per day	Count	9	5	16	30
	Community %	37.5%	14.7%	44.4%	31.9%
Total	Count	24	34	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

39. How many times did you eat cheese or other dairy products this week?

		Garden Hill	St. Theresa Point	Norway House	**Total**
none	Count	3	6		9
	Community %	12.5%	17.6%		9.6%
1 per week	Count	3	3	1	7
	Community %	12.5%	8.8%	2.8%	7.4%
1 every few days	Count	2	9	6	17
	Community %	8.3%	26.5%	16.7%	18.1%
1 or 2 per day	Count	9	14	23	46
	Community %	37.5%	41.2%	63.9%	48.9%
3 or 4 per day	Count	7	2	6	15
	Community %	29.2%	5.9%	16.7%	16.0%
Total	Count	24	34	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

40. Do you, or someone in your family:

a) hunt/trap?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	6	7	5	18
	Community %	25.0%	20.0%	13.9%	18.9%
yes	Count	17	25	31	73
	Community %	70.8%	71.4%	86.1%	76.8%
don't know	Count	1	3		4
	Community %	4.2%	8.6%		7.2%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

b) fish?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	5	6	7	18
	Community %	20.8%	17.1%	19.4%	18.9%
yes	Count	18	28	29	75
	Community %	75.0%	80.0%	80.6%	78.9%
don't know	Count	1	1		2
	Community %	4.2%	2.9%		2.1%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

c) garden?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	21	26	24	71
	Community %	95.5%	76.5%	68.6%	78.0%
yes	Count	1	8	11	20
	Community %	4.5%	23.5%	31.4%	22.0%
Total	Count	22	34	35	91
	Community %	100.0%	100.0%	100.0%	100.0%

d) gather (berries or other wild food)?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	7	5	6	18
	Community %	33.3%	15.6%	16.7%	20.2%
yes	Count	14	27	30	81
	Community %	66.7%	84.4%	83.3%	79.8%
Total	Count	21	32	36	89
	Community %	100.0%	100.0%	100.0%	100.0%

41. If vitamin D or calcium was put in a food you eat and you couldn't tell that it was there except for on the package label:

a) would you continue to eat this food if you eat it now?

		Garden Hill	St. Theresa Point	Norway House	**Total**
yes	Count	17	32	35	84
	Community %	70.8%	91.4%	97.2%	88.4%
don't know	Count	7	3	1	11
	Community %	29.2%	8.6%	2.8%	11.6%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

b) would you try to eat more of that food if you didn't normally eat much of it?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	2	6	1	9
	Community %	8.3%	17.1%	2.9%	9.6%
yes	Count	12	19	29	60
	Community %	50.0%	54.3%	82.9%	63.8%
don't know	Count	10	10	5	25
	Community %	41.7%	28.6%	14.3%	26.6%
Total	Count	24	35	35	94
	Community %	100.0%	100.0%	100.0%	100.0%

42. Do you breast feed your babies?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	1	3	11	15
	Community %	5.6%	12.5%	42.3%	22.1%
yes	Count	17	21	15	53
	Community %	94.4%	87.5%	57.7%	77.9%
Total	Count	18	24	26	68
	Community %	100.0%	100.0%	100.0%	100.0%

43. If yes, for how long did you breast feed your last baby?

Months Breastfed		Garden Hill	St. Theresa Point	Norway House	**Total**
1	Count	1	1	1	3
2	Count		2	3	5
3	Count		3	1	4
4	Count		1		1
5	Count		1	3	4
6	Count		1	1	2
0-6 mos	Count	1	9	9	19
	Community %	6.3%	69.2%	60.00%	43.2%
7	Count	1			1
12	Count	5	1		6
7-12 mos	Count	6	1	0	7
	Community %	37.5%	7.7%	0.0%	15.9%
14	Count			1	1
18	Count	7			7
24	Count	2	2		4
13-24 mos	Count	9	2	1	12
	Community %	56.3%	15.4%	6.7%	27.3%
30	30 Count			1	1
36	36 Count			2	2
44	44 Count			1	1
60	Count		1	1	2
25-60 mos	Count	0	1	5	6
	Community %	0.0%	7.7%	33.3%	13.6%
Total	Count	16	13	15	44
	Community %	100.0%	100.0%	100.0%	100.0%

44. Did you feed your last baby:
a) evaporated milk?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	12	11	8	31
	Community %	70.6%	45.8%	38.1%	50.0%
yes	Count	5	13	13	31
	Community %	29.4%	54.2%	61.9%	50.0%
Total	Count	17	24	21	62
	Community %	100.0%	100.0%	100.0%	100.0%

b) whole milk?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	17	21	9	47
	Community %	100.0%	91.3%	45.0%	78.3%
yes	Count		2	11	13
	Community %		8.7%	55.0%	21.7%
Total	Count	17	23	20	60
	Community %	100.0%	100.0%	100.0%	100.0%

c) 2%, 1% or skim milk?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	6	17	5	28
	Community %	35.3%	70.8%	26.3%	46.7%
yes	Count	11	7	14	32
	Community %	64.7%	29.2%	73.7%	53.3%
Total	Count	17	24	19	60
	Community %	100.0%	100.0%	100.0%	100.0%

d) infant formula (baby milk, not pablum)?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	3	7	6	16
	Community %	16.7%	29.2%	23.1%	23.5%
yes	Count	15	17	20	52
	Community %	83.3%	70.8%	76.9%	76.5%
Total	Count	18	24	26	68
	Community %	100.0%	100.0%	100.0%	100.0%

45. How many months old was your last baby when you started to give:

a) formula or milk (other than breast milk)?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	1	3	5	9
	Community %	5.6%	13.0%	20.0%	13.6%
under 2 months	Count	2	10	11	23
	Community %	11.1%	43.5%	44.0%	34.8%
3 to 5 months	Count	3	5	3	11
	Community %	16.7%	21.7%	12.0%	16.7%
6 or more months	Count	12	5	6	23
	Community %	66.7%	21.7%	24.0%	34.8%
	Count	18	23	25	66
	Community %	100.0%	100.0%	100.0%	100.0%

b) food other than milk?

		Garden Hill	St. Theresa Point	Norway House	**Total**
don't know	Count		1		1
	Community %		4.3%		1.6%
under 2 months	Count		3	1	4
	Community %		13.6%	4.3%	6.3%
3 to 5 months	Count	6	11	9	26
	Community %	33.3%	50%	39.1%	40.6%
6 or more months	Count	12	8	13	33
	Community %	66.7%	36.4%	56.5%	51.6%
Total	Count	18	22	23	64
	Community %	100.0%	100.0%	100.0%	100.0%

46. What foods are especially good for pregnant women and did you eat these food during your last pregnancy?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	2		1	3
	Community %	12.5%		3.8%	4.5%
yes	Count	13	22	25	60
	Community %	81.3%	91.7%	96.2%	90.9%
don't know	Count	1	2		3
	Community %	6.3%	8.3%		4.5%
Total	Count	16	24	26	66
	Community %	100.0%	100.0%	100.0%	100.0%

47. Did you give vitamin drops to your last baby?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	4	2	3	9
	Community %	23.5%	8.3%	11.5%	13.4%
yes	Count	12	21	23	56
	Community %	70.6%	87.5%	88.5%	83.6%
don't know	Count	1	1		2
	Community %	5.9%	4.2%		3.0%
Total		17	24	26	67
		100.0%	100.0%	100.0%	100.0%

48. If yes, how often did you give vitamin drops to your last baby?

		Garden Hill	St. Theresa Point	Norway House	**Total**
never	Count	3		1	4
	Community %	20.0%		4.2%	6.6%
rarely	Count		4		4
	Community %		18.2%		6.6%
often	Count	6	5	4	15
	Community %	40.0%	22.7%	16.7%	24.6%
most days	Count	5	6	15	26
	Community %	33.3%	27.3%	62.5%	42.6%
always	Count	1	7	4	12
	Community %	6.7%	31.8%	16.7%	19.7%
Total	Count	15	22	24	61
	Community %	100.0%	100.0%	100.0%	100.0%

49. Do you give milk to your children over 1 year of age?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	1	2		3
	Community %	5.9%	8.3%		4.5%
yes	Count	16	22	25	63
	Community %	94.1%	91.7%	96.2%	94.0%
don' t know	Count			1	1
	Community %			3.8%	1.5%
Total	Count	17	24	26	67
	Community %	100.0%	100.0%	100.0%	100.0%

50. How many of your children have gone to Winnipeg to have dental work?

		Garden Hill	St. Theresa Point	Norway House	**Total**
0	Count	12	9	22	43
	Community %	70.6%	39.1%	84.6%	65.2%
1	Count	4	6	2	12
	Community %	23.5%	26.1%	7.7%	18.2%
2	Count	1	5	2	8
	Community %	5.9%	21.7%	7.7%	12.1%
3	Count		3		3
	Community %		13.0%		4.5%
Total	Count	17	23	26	66
	Community %	100.0%	100.0%	100.0%	100.0%

51. How many of your children have had general anaesthetic for dental surgery?

		Garden Hill	St. Theresa Point	Norway House	**Total**
0	Count	13	9	13	35
	Community %	76.5%	39.1%	5.0%	53.0%
1	Count	3	6	7	16
	Community %	17.6%	26.1%	26.9%	24.2%
2	Count	1	6	5	12
	Community %	5.9%	26.1%	19.2%	18.2%
3	Count		2		2
	Community %		8.7%		3.0%
4	Count			1	1
	Community %			3.8%	1.5%
Total	Count	17	23	26	66
	Community %	100.0%	100.0%	100.0%	100.0%

52. Do you consider yourself healthy?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	2	6	2	10
	Community %	8.7%	17.1%	5.6%	10.6%
yes	Count	20	19	30	69
	Community %	87.0%	54.3%	83.3%	73.4%
don' t know	Count	1	10	4	15
	Community %	4.3%	28.6%	11.1%	16.0%
Total	Count	23	35	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

53. Do you have bone pain?

		Garden Hill	St. Theresa Point	Norway House	Total
no	Count	21	30	23	74
	Community %	95.5%	85.7%	63.9%	79.6%
yes	Count	1	5	13	19
	Community %	4.5%	14.3%	36.1%	20.4%
Total	Count	22	35	36	93
	Community %	100.0%	100.0%	100.0%	100.0%

54. Do you have weak muscles in your arms or legs?

		Garden Hill	St. Theresa Point	Norway House	Total
no	Count	20	30	26	76
	Community %	87.0%	85.7%	72.2%	80.9%
yes	Count	1	3	9	13
	Community %	4.3%	8.6%	25.0%	13.8%
don't know	Count	2	2	1	5
	Community %	8.7%	5.7%	2.8%	5.3%
Total	Count	23	35	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

55. Do you have numbness/tingling of hands/feet/mouth?

		Garden Hill	St. Theresa Point	Norway House	Total
no	Count	21	30	28	79
	Community %	91.3%	85.7%	77.8%	84.0%
yes	Count	1	4	6	11
	Community %	4.3%	11.4%	16.7%	11.7%
don't know	Count	1	1	2	4
	Community %	4.3%	2.9%	5.6%	4.3%
Total	Count	23	35	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

56. Do you have trouble getting up to stand?

		Garden Hill	St. Theresa Point	Norway House	Total
no	Count	22	33	28	83
	Community %	95.7%	97.1%	77.8%	89.2%
yes	Count	1	1	7	9
	Community %	4.3%	2.9%	19.4%	9.7%
don't know	Count			1	1
	Community %			2.8%	1.1%
Total	Count	23	34	36	93
	Community %	100.0%	100.0%	100.0%	100.0%

57. Do you walk with a limp?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	22	32	36	90
	Community %	95.7%	91.4%	100.0%	95.7%
yes	Count	1	3		4
	Community %	4.3%	8.6%		4.3%
Total	Count	23	35	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

58. Do, or did, you have a dislocated hip?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	23	34	36	93
	Community %	100.0%	97.1%	100.0%	98.9%
yes	Count		1		1
	Community %		2.9%		1.1%
Total	Count	23	35	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

59. Do you have diabetes?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	21	26	31	78
	Community %	91.3%	74.3%	86.1%	83.0%
yes	Count	2	5	4	11
	Community %	8.7%	14.3%	11.1%	11.7%
don't know	Count		4	1	5
	Community %		11.4%	2.8%	5.3%
Total	Count	23	35	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

60. Would you be willing to change your diet and lifestyle in ways that would increase your vitamin D and calcium levels?

		Garden Hill	St. Theresa Point	Norway House	**Total**
yes	Count	14	35	32	81
	Community %	58.3%	100.0%	94.1%	87.1%
don't know	Count	10		2	12
	Community %	41.7%		5.9%	12.9%
Total	Count	24	35	34	93
	Community %	100.0%	100.0%	100.0%	100.0%

61. Which of the following changes would you be willing to make:

a) eat more dairy products?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	1	2	1	4
	Community %	4.2%	5.7%	2.8%	4.2%
yes	Count	17	33	35	85
	Community %	70.8%	94.3%	97.2%	89.5%
don't know	Count	6			6
	Community %	25.0%			6.3%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

b) take vitamins regularly?

		Garden Hill	St. Theresa Point	Norway House	**Total**
yes	Count	17	31	36	84
	Community %	73.9%	88.6%	100.0%	89.4%
don't know	Count	6	4		10
	Community %	26.1%	11.4%		10.6%
Total	Count	23	35	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

c) take a high dose vitamin supplement once a year?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count		2	2	4
	Community %		5.7%	5.6%	4.3%
yes	Count	15	22	29	66
	Community %	65.2%	62.9%	80.6%	70.2%
don't know	Count	8	11	5	24
	Community %	34.8%	31.4%	13.9%	25.5%
Total	Count	23	35	36	94
	Community %	100.0%	100.0%	100.0%	100.0%

d) spend more time in the sun?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	2	3	5	10
	Community %	8.3%	8.6%	13.9%	10.5%
yes	Count	17	25	25	67
	Community %	70.8%	71.4%	69.4%	70.5%
don't know	Count	5	7	6	18
	Community %	20.8%	20.0%	16.7%	18.9%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

e) support efforts to have vitamin D and calcium added to common foods?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	1			1
	Community %	4.2%			1.1%
yes	Count	16	32	29	77
	Community %	66.7%	91.4%	80.6%	81.1%
don't know	Count	7	3	7	17
	Community %	29.2%	8.6%	19.4%	17.9%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

f) support efforts to make dairy products more affordable?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count	1			1
	Community %	4.2%			1.1%
yes	Count	17	33	36	86
	Community %	70.8%	94.3%	100.0%	90.5%
don't know	Count	6	2		8
	Community %	25.0%	5.7%		8.4%
Total	Count	24	35	36	95
	Community %	100.0%	100.0%	100.0%	100.0%

g) try to find non-dairy, diet sources of vitamin D and calcium?

		Garden Hill	St. Theresa Point	Norway House	**Total**
no	Count		2	2	4
	Community %		5.7%	5.7%	4.3%
yes	Count	18	27	30	75
	Community %	75.0%	77.1%	85.7%	79.8%
don't know	Count	6	6	3	15
	Community %	25.0%	17.1%	8.6%	16.0%
Total	Count	24	35	35	94
	Community %	100.0%	100.0%	100.0%	100.0%