Diet diversity and infectious illness in young children in rural Southern Madagascar

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Abstract

The objective of the study was to determine whether diet diversity can predict the prevalence of infectious disease in children under 6-years in a rural African village. The study took place in Southern Madagascar. Dietary diversity, health and socio-economic interviews were administered to 77 mothers of children under 6 years old and who no longer breastfed. The diet diversity score was analysed along with socio-economic variables as predictors of the number of days a child had spent ill from an infectious disease in the past month. Meat and wild food variety, as well as education of the mother, childhood vaccinations and access to latrines and clean water were found to be important predictors of reduced disease risk in children. The study identifies conservation of natural resources and development of health and education facilities as priorities for the reduction of child mortality from infectious disease.

Abstrait

L'objectif de l'étude était de déterminer si la diversité du régime peut prévoir le quota des maladies infectieuses touchant les enfants en dessous de 6 ans dans un village Africain. L'étude a eu lieu au Madagascar du Sud. Soixante-dix-sept mères d'enfants en dessous de 6 ans et qui ne tètent plus ont été interviewées au sujet de la diversité alimentaire, de la santé chez l'enfant et de l'économie sociale de la ménage. Le nombre de jours de malades du mois précédent dépendait de la diversification des aliments et des paramètres socio-économiques. La diversité des produits carnassiers et les aliments non cultivés était facteurs d'état maladifs chez les enfants ainsi que le niveau éducatif de la mère, la politique de vaccinations et l'accès à l'hygiène et l'eau potable. Cette étude identifie la conservation des ressources naturelles et de développent de la santé et de la facilité de l'éducation comme prioritaires pour la diminution de la mort enfantine de maladies infectieuses.

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Literature Review

Context

This study is concerned with the high rate of childhood morbidity and mortality in the developing world. It focuses on diet, and in particular the composition of wild plants within the diet, and their potential to influence morbidity rates in children.

The site chosen for this research is Madagascar, an island separated from mainland Africa by the Mozambique Canal, but connected to the mainland by many of the same problems facing other Sub-Saharan African countries. Although the proportion of people living in poverty in the world has decreased over the past decade, the number of people living in poverty in Africa has increased (United Nations Human Development Report, 2003). Development of Sub-Saharan Africa has been stifled by HIV/AIDS and epidemics of other infectious diseases, drought and complacence of industrialised countries to the plight of the continent. In response to the high levels of poverty around the world, Millennium Development Goals (MDGs) were adopted by all member states of the United Nations in September 2000. Goal 4 of the MDGs 'To reduce by two-thirds, between 1990 and 2015, the under-five mortality rate', provides a backbone to this thesis.

In focussing on diet, this study explores solutions to alleviating poverty and childhood morbidity found within the community such as the utilisation of natural resources like wild plants and the promotion of traditional knowledge.

Introduction to the Literature Review

The introduction to this thesis and literature review that follows explores the significance of infectious diseases in childhood mortality and how a lack of adequate nutrition is the major contributor to rates of infectious disease in children. Nutrients in the diet affect susceptibility to infections by acting on the immune system. To demonstrate the importance of diet in immunity, the effect of certain key nutrients on the immune system will be examined. Various methods of assessing the intake and adequacy of these and other nutrients will then be reviewed and in this, the concept of dietary diversity shall be explained. A section on the significance of wild plants to the diet in many communities worldwide will conclude the literature review.

A brief section on the rationale of the study will tie together all the ideas discussed in the various sections into a specific hypothesis and study objective.

Poverty and Childhood Morbidity

It is estimated that 10.6 million children died in 2003 before the age of five[1]. Many of these deaths were preventable and over 50% were caused by infectious diseases such as acute respiratory infections, diarrhoea, measles and malaria. In ten prospective cohort studies from Sub-Saharan Africa and Asia with data on anthropometric status and cause of death assembled to calculate relative risk of mortality from under-nutrition for each cause of death, 52.5% of all deaths in

[1] Figure taken from the United Nations Children's Fund (UNICEF) State of the World's Children 2005. Accessed online at http://www.unicef.org/publications/index_24432.html

children were attributable to low weight-for-age scores resulting from under-nutrition (Caulfield *et al.*, 2004). This percentage varied by cause of death: 60.7% for diarrhoea, 57.3% for malaria, 52.3% for pneumonia and 44.8% for measles.

The high rate of childhood mortality in the world is a global tragedy that requires urgent attention by the international community. Madagascar, like many other Sub-Saharan countries has particularly high rates of child mortality. The latest figures for Madagascar available from UNICEF estimate that in 2003, 126 children of every 1000 live births died before the age of five. Madagascar has been identified as a Profile 2 country where malaria accounts for over 10% of deaths in children under five and AIDS accounts for fewer that 10% of these deaths. Consequently, the proportion of deaths in under-fives is estimated to be between 20% and 26% for each of the following causes: diarrhoea, respiratory infections, malaria and neonatal disorders (Black *et al.*, 2003).

Many factors contribute to the toll of childhood infection. These are poverty, lack of access to safe drinking water, poor sanitation, a lack of health services and vaccination programmes as well as childhood malnutrition. Although Madagascar's economy has grown stronger in recent years, many rural poor have yet to notice changes in their daily lives. Madagascar is one of 13 countries in which less than half the population has access to safe drinking water and sanitation facilities[2]. Access for villagers to health services and vaccination programmes is often difficult because a poor road infrastructure. Until institutions and infrastructure that permit better living conditions are present, a

[2] UNICEF (United Nations Children's Fund). The State of the World's Children 2005/Statistics. Accessed online at http://www.unicef.org/sowc05/english/statistics.html

better understanding of the use and potential of existing resources could make a difference towards alleviating childhood mortality and morbidity.

Malnutrition and Childhood Morbidity

Malnutrition is a lack of sufficient calories to support growth, development or daily energy expenditure and occurs when one or more essential nutrients are present in insufficient quantities in the diet. Infectious disease can cause malnutrition from a) excess nutrient losses through sweating, diarrhoea, vomiting and bleeding b) from an increased requirement of nutrients for the proliferation of immune system cells and c) from a decreased rate of absorption in a damaged gastro-intestinal tract. Malnutrition can also be the cause of infection and it has been established that nutrient deficiencies are commonly associated with impaired immune systems (Fraker, 2000).

Direct evidence for the link between nutrition and infectious disease is observable in studies that investigate dietary interventions and the occurrence and severity of various infectious diseases. There are also significant correlations between anthropometrical indicators of malnutrition and increased levels of infection. One such study in Gambia found children who were stunted, a symptom of chronic malnutrition diagnosed by low height-for-age z-scores, had more frequent malarial episodes that children who were not stunted ($p<0.01$) (Deen *et al.*, 2002). Another study in Gambia found that a higher prevalence of diarrhoea could be seen among children with a low height-for-age (Tomkins *et al.*, 1989).

Protein energy malnutrition (PEM) affects immunity by causing thymic atrophy, lymphopoenia and reductions in cell and antibody-mediated responses (Fraker, 2000). PEM is accompanied by deficiencies in micronutrients and many of these are required for the functioning of the immune system. Of these nutrients, zinc, vitamin A and iron have been studied extensively and results demonstrate the importance of these nutrients on the immune system and their role in modulating infectious diseases. Evidence for the role of these nutrients in the immune system shall now be reviewed.

Micronutrients and the Immune System

Vitamin A has an effect on the immune system through it's action as a regulator of gene expression. It influences cell differentiation and proliferation. Diarrhoea, pneumonia and measles are often observed in children preceding or showing signs of vitamin A deficiency (Stephenson, 2001).

The case for vitamin A affecting the immune system can be observed when vitamin supplements are administered in controlled clinical trials. Vitamin A supplements have been shown to be effective in children with diarrhoeal diseases and apparent PEM by increasing IgA response in the intestine and increasing cytokine production, both of which are lowered as a result of PEM (Donnen *et al.*, 1998). Hussey *et al.* in 1990 carried out a trial in South Africa where children under 13 years with acute measles were supplemented with vitamin A. The study showed that the length of pneumonia bouts was halved and diarrhoeal episodes reduced by 30% in the supplemented group compared to the control ($p<0.001$). Shankar *et al.* in 1999 showed that malarial febrile episodes were reduced in frequency ($p=0.0013$) and the time to the first malarial episode increased ($p=0.03$) in supplemented children compared to the placebo. In another placebo-controlled trial, Fawazi *et al.* (1998) found that HIV-infected pregnant women in Tanzania had a greater increase in T-cells when supplemented with vitamin A than the control ($p<0.001$). The outcome of these and other studies have prompted UNICEF (2004) to estimate that improving the vitamin A status of children can reduce death from measles by 50% and reduce death from diarrhoea by 40%[3].

An international effort in vitamin A supplementation has been made throughout the developing world. The percentage of children between 6 months to 5 years old receiving at least one large-dose vitamin A supplementation per year in Madagascar in 2000 is 85%[4]. The same source, however, estimates that sub-clinical vitamin A deficiency in Madagascar was 42% in children under 6 in 2004. This disparity could be explained by regional differences in micronutrient status in Madagascar due to differing environments resulting from various climactic zones.

Zinc is another micronutrient that is known to be essential for normal functioning of immune system cells. Zinc deficiency can cause decreased antibody production, impaired T-cell activity and decrease the efficacy of the thymus (Wellinghausen, 2001). Strand *et al.* (2004) measured plasma zinc

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[3] UNICEF (2004) .*Fact sheet on vitamin A.* Accessed online: http://www.unicef.org.nutrition/vitamina.html

[4] Data for Madagascar from the Vitamin and Mineral Deficiency Report published by the Micronutrient Initiative and accessed online: http://www.micronutrient.org/VMD/Madagascar.asp

concentrations in Nepalese children suffering from acute diarrhoea and observed plasma zinc concentrations inversely proportional to body temperature. Eighty-one children supplemented with 10mg zinc in Peru had fewer episodes of diarrhoea, respiratory illnesses and fever than a placebo group (Penny *et al.*, 2004). Black *et al.* (2003) has summarised that "Zinc deficiency increases the risk of mortality from diarrhoea, pneumonia and malaria by 13-21%."

A cross-sectional study in rural Tanzania found a significant association between anaemia and markers of infection such as C-reactive protein (Adjusted Odd Ratio = 3.5), and anaemia and a positive malaria blood slide (odd ratio=2.7) (Hinderaker *et al.*, 2002). Evidence also suggests (Oppenheimer *et al.*, 1984) that iron supplementation predisposes the onset or severity of malaria infection, however, a supplement of low-dose iron in a randomized controlled trial in Zanzibar found no increase in prevalence of malaria or severity of the infection in the iron-supplemented group (Mebratu *et al.*, 2004).

Phytochemicals in Common Foods and the Immune System

In addition to micronutrient status, other components of the diet such as some phytochemicals, can also affect immunity and may be important for health. Some classes of phytochemicals occur in common foods and their effect on the immune system has been studied. Tea, coffee and cocoa are all rich in flavonoids. Flavonoids and their health benefits are reviewed by Yao *et al.* (2004) and are reported therein to have anti-inflammatory and antiviral effects in addition to their better known benefits as antioxidants in the prevention of chronic disorders.

Carotenoids are mainly found in yellow to red coloured plant foods. Beta-carotene is an example of a carotenoid that has been investigated in relation to its effect on the immune system. The evidence for the role of beta-catotene in immunity is far from conclusive, however some studies have found it to have immuno-stimulatory effects (Schmitz & Chevaux, 2001). The effects of beta-carotene may be confounded by the fact that it is a precursor to vitamin A, which has known immuno-modulatory effects as already discussed.

The evidence seems clear that adequacy of specific nutrients is required for normal functioning of the immune system. It therefore seems reasonable to predict that a diet adequate in all essential nutrients will favourably affect resistance to infectious disease.

Measuring Nutrient Adequacy

Nutrient adequacy is the intake of a particular nutrient as a proportion of the daily reference intake of that nutrient, and depends on the subject's age, sex and whether they are pregnant or lactating. The nutrient adequacy of a diet is usually assessed using 24-hour dietary recalls on two or three separate days. The 24-hour recall includes the quantity of each food ingredient consumed over that time from which the intake of individual nutrients can be calculated.

Twenty-four-hour recalls put a substantial burden on the interviewee, are lengthy and relatively expensive to perform and analyse. There is an interest in devising an alternative questionnaire that can be used in settings where a rapid assessment of diet quality is required (Hatloy *et al.* 1998).

A 7-day food frequency questionnaire (7DFFQ) measures consumption over a week and can also assess diet diversity. A 7DFFQ could simply count all food items consumed in the past 7 days giving each item an equal weight. It could also include the frequency that each food item is consumed or the amount of each food item that was consumed. Definitions of diet variety and diet diversity that can be derived from the 7DFFQ are inconsistent between researchers. Hatloy *et al.* (1998) use the term *food variety* for the total number of different ingredients consumed over 7 days and *diet diversity* for the number of different food groups consumed in the same time period. These terms shall be used according to the above definition throughout this thesis, unless otherwise specified.

Many national nutritional guidelines recommend eating a wide variety of foods, although the emphasis in recent years has been on eating a variety of nutrient rich foods and fruits and vegetables in order not to promote over-eating (USDA, 2005). Consuming a wide variety of foods increases the likelihood that all essential nutrients are included in the diet along with some beneficial non-essential nutrients (Tucker, 2001). Measuring dietary diversity is a rapid procedure. If diversity of a diet can be equated to the quality of the diet in terms of adequacy of the essential nutrients, a dietary diversity score could be a useful and rapid assessment of health.

Several studies have investigated the link between diet diversity and nutrient adequacy in a North American population. In rural Iowa, Marshall *et al.* (2001) found that low diet variety in elderly people was associated with the number of nutrients consumed at inadequate levels ($r=0.498$; $p<0.05$). Another example from a developed country is a study by Foote *et al.* (2004) who analysed data from 4969 men and 4800 women and found variety in food items and diversity of food groups was significantly correlated to a mean probability of adequacy of 15 micronutrients. In a recent comprehensive review of studies done in developed countries, intakes of fruit, vegetables, fish, whole grain and poultry were found to relate to nutrient intake (Kant, 2004). However, when a health outcome such as disease risk was assessed, the effect of diet was tempered by other variables such as age, income and education (Kant, 2004).

Studies on diet diversity and nutrient adequacy have been done in many developing countries and in rural and urban settings. Hatloy *et al.* (1998) conducted a study in an urban area of Mali on food variety and nutrient adequacy of 77 children between 13 and 56 months old. The study found that food variety and diet diversity correlated significantly with nutrient adequacy of fat energy, vitamin C and vitamin A. Both measures are also correlated with a mean nutrient adequacy of 10 essential nutrients. Torheim *et al.* (2004) conducted a similar study using 7-day food frequency questionnaire in rural Mali with 502 subjects from 319 households aged between 15 and 45 years. Food variety and diet diversity correlated with mean adequacy of 10 nutrients considered. They also found correlations between the number of food items within each food group and mean nutrient adequacy. The number of vegetables and milk items, for example, when correlated with mean nutrient adequacy, had Pearson's correlation coefficients of 0.31 and 0.30 respectively. Spigelski (2004) compared nutrient intakes calculated from a 24-hour recall with food diversity recorded in a 1-Day Food Frequency Questionnaire and a 7DFFQ. The study, carried out in peri-urban Senegal, found that 7DFFQ diet diversity scores correlated most closely with the nutrient intakes of 8 micronutrients.

A study in Bolivia on 117 boys from La Paz found that increased number of food items consumed over 24 hours correlated with the nutrient adequacy of all nutrients except non-heme iron and an increase in food variety correlated with increased intakes for all nutrients except for niacin, riboflavin and iron (Moreno-Black, 1983). In Vietman, Ogle *et al.* (2001) found significantly higher intakes of protein, fat and 9 micronutrients in rural community with a food variety score of more than 21 over 7 days. They also found that women consuming from at least 8 food groups had significantly higher intakes of protein, niacin, vitamin C and zinc. They noted an importance of wild vegetables in the diet of this population and these contributed significantly to iron and carotene intakes.

Ruel (2003) reviewed six other articles from developing countries all showing that nutrient adequacy correlates to food variety. The cut off points for diversity at which nutrient adequacy is reached is different for each study and the division of foods into different food groups also differs depending on the context at the location, however, the evidence for an association appears fairly robust.

Measures other than the intake of individual nutrients can indicate the adequacy of a diet and overall health status. Examples of these are height-for-age Z-scores (HAZ), giving long-term diet sufficiency status in children, weight-for-height Z-scores (WHZ) and mid-upper arm circumference (MUAC). Arimond and Ruel (2004) review research relating dietary diversity to HAZ and found dietary diversity to be significantly associated to HAZ in four of the six papers conducted in Sub-Saharan Africa. The children in these studies were between 6 and 27 months old. Onyango (2003) reports on a study in Niger by Tarini *et al.* (1999) on 60 children between ages 2 and 4. The study found an association between food group diversity based on 11 food groups and WHZ. Onyango (2003) comments that the main objective of the Niger study was vitamin A intake, so the possible omission of a full food list coupled with the small sample size make the data hard to interpret for the purpose of all nutrients.

A prospective study in the USA measured diet quality, in this case food variety, and mortality in a cohort of 42254 women with a median follow-up of 5.6 years. The study called the food variety measure a Recommended Food Score (RFS), as it measured consumption of foods that are recommended by the current US guidelines. Women who had the highest intake level of recommended foods had a 30% reduction in risk of mortality from all causes (Kant *et al.*, 2000). In one study in Indonesian children, height-for-age scores were found to be improved in children who consumed green leafy vegetables daily compared to those who ate green leaves less frequently (Gross *et al.*, 1996). In these last two studies, diversity and frequency of a particular sub-set of foods was focussed on in relation to health. This is yet another way of perceiving dietary diversity along with food group diversity and food variety.

The Contribution of Wild Plants

Before the agricultural revolution, wild plants were an important part of the human diet. Since the development of agriculture, the diversity of plants in the diet has reduced to the point that 80% of total energy in the diet is obtained from 12 crop species (Grivetti & Ogle, 2000). The supply of nutrient-rich traditional plant foods is under threat in many areas of the world where traditional foods such as wild plants are being replaced by market foods. This undermines the possibility of a balanced diet for many people around the world and results in reduced food security (Lykke *et al.*, 2002). Reduced food security due to a reliance on limited plant diversity increases risks of famine. Harvests of crop plants occasionally fail due to climatic or pest disturbances, and traditional knowledge about edible wild plants that could relieve a hunger crisis is lost through the under-use of these resources. Consumption of wild plants, however, may not be useful in response to an emergency food shortage but can be a valuable part of a regular diet as they may confer vital nutritional and medicinal properties. Evidence for these properties are discussed below.

Many common food ingredients have been found to have medicinal properties. Examples include the antibacterial properties of ginger and chilli pepper and antimicrobial components of onion and garlic (Etkin & Ross, 1991). Domesticated plants are generally considered relatively inert in medicinal properties, having lost the ability to produce many secondary metabolites necessary for defence against predators and pathogens, while wild plants in the diet can be interesting and often overlooked by researchers (Etkin & Ross, 1991).

These dietary components, while often consumed in low quantities, may be consumed at high enough frequencies to lead to a beneficial health effect from active compounds contained in the plants.

Much of the research into pharmacologically-active plant properties is directed by reports of plant properties by the local population. Parker (2004) tested plant extracts from Kenya described by traditional healers as having curative properties and antiviral activity against measles. Significant activity was found in these plants in contrast to no measurable activity in a control group of non-medicinal plants. A valorization of a plant used to treat malaria in Eastern Madagascar found 5 separate alkaloids all active against the malaria pathogen *in vitro* (Randrianarivelojosia *et al.*, 2003). Rasoanaivo *et al.* (2004) screened 190 plants from Madagascar, of which 51 were known to be used to treat malaria in traditional medicine, for antiplasmodial compounds. These plants were taken from different ecological regions of Madagascar. Thirty-nine plants had activity *in vitro* against the malaria pathogen *Plasmosium falciparum*. Twelve of these were already in use as anti-malarials by local communities.

Apart from medicinal properties, wild plants and traditional crops can be important in completing basic nutritional requirements. Traditional cultivated plants in East Africa such as amaranth, red sorrel and the cowpea contribute significant amounts of protein, calcium, iron, carotene and vitamin C (Gura, 1986). Fleuret (1979) conducted comprehensive dietary surveys in three villages in the Lesotho region of Tanzania, spanning up to 13 consecutive days and over three seasons. The study found that wild foliage plants were consumed in 32% of all meals. The study concluded that wild foliage plants, although often ignored in dietary surveys in the region, contribute significantly to amounts of carotene, iron, calcium and protein in the diet. Ogle *et al.* (2003) investigated wild vegetables in the diet of women living at the Mekong delta in Vietnam and, as in the studies previously reported, these plants contributed significantly to intakes of carotene, vitamin C, calcium and iron. In South Africa, High and Shackleton (2000) compared the value of wild and domestic plants in home gardens and found that wild resources are important nutritionally when eaten by the household, and economically when sold for cash. Ayirebi women in Ghana spent an average of 7.9 hours per week gathering wild foods such as plants, honey and molluscs. In the Condo region of Zimbabwe, Campbell (1987) found that although wild fruits did not appear in 24-hour recalls, 95% of households reported eating them. Of these households, 52% ate wild fruits for taste, 61% ate them for medicinal or nutritional benefits and 15% ate them to prevent hunger. These studies show that wild fruits, leaves and vegetables are an important nutritional component of many diets around the world.

Etkin & Ross (1991) stress the importance of adopting a dualistic approach, incorporating nutrition and pharmacology, when considering the consumption of wild plants in a diet. In a study in the Hausa region of Nigeria in 1982, these researchers found that of 107 plants used as medicines for gastrointestinal disorders, 49% were also used as food. In Vietnam, Ogle *et al.* (2001) recorded medicinal uses for 49% of the 94 wild vegetables recorded in a dietary questionnaire. Johns *et al.* (1995) found significant anti-giardial properties in *Solanum nigrum*, a leaf consumed commonly as food in Kenya.

The focus on wild plants in this study adds an interesting dimension to this study. Madagascar is rich in biodiversity and many organisations are involved in trying to protect and preserve this diversity. If these natural resources can be shown to be valuable for children's health, the case for their preservation can be strengthened. Reliance on local resources can decrease dependence on a supply of imported foods and increase self-sustainability and food security (Johns & Sthapit, 2004).

Rationale of the Study

The current study couples the premise that diet diversity improves nutrient adequacy with the knowledge that nutrients affect the immune system and aims to observe a link between diet diversity and illness. The hypothesis is that an increase in diet quality leads to an improvement in health. The health measure in this study is number of days ill from infectious disease in the past month. In focusing on children under 6-years old, the study focuses on an age when infectious diseases are common. The measure of diet quality is by food item variety, food group diversity and the diversity within food groups. In order to test this hypothesis, the study aimed to capture the whole diet including wild plants consumed as food or medicine.

The study area was chosen for its rich biodiversity and the largely unstudied use of this biodiversity as food by the local communities. This study presents a possible case for a simple food diversity questionnaire being used as a basis for a rapid assessment of health in a community. The goal is to emphasise the importance of species diversity and traditional knowledge of those species in maintaining the health of the community.

Study Objective

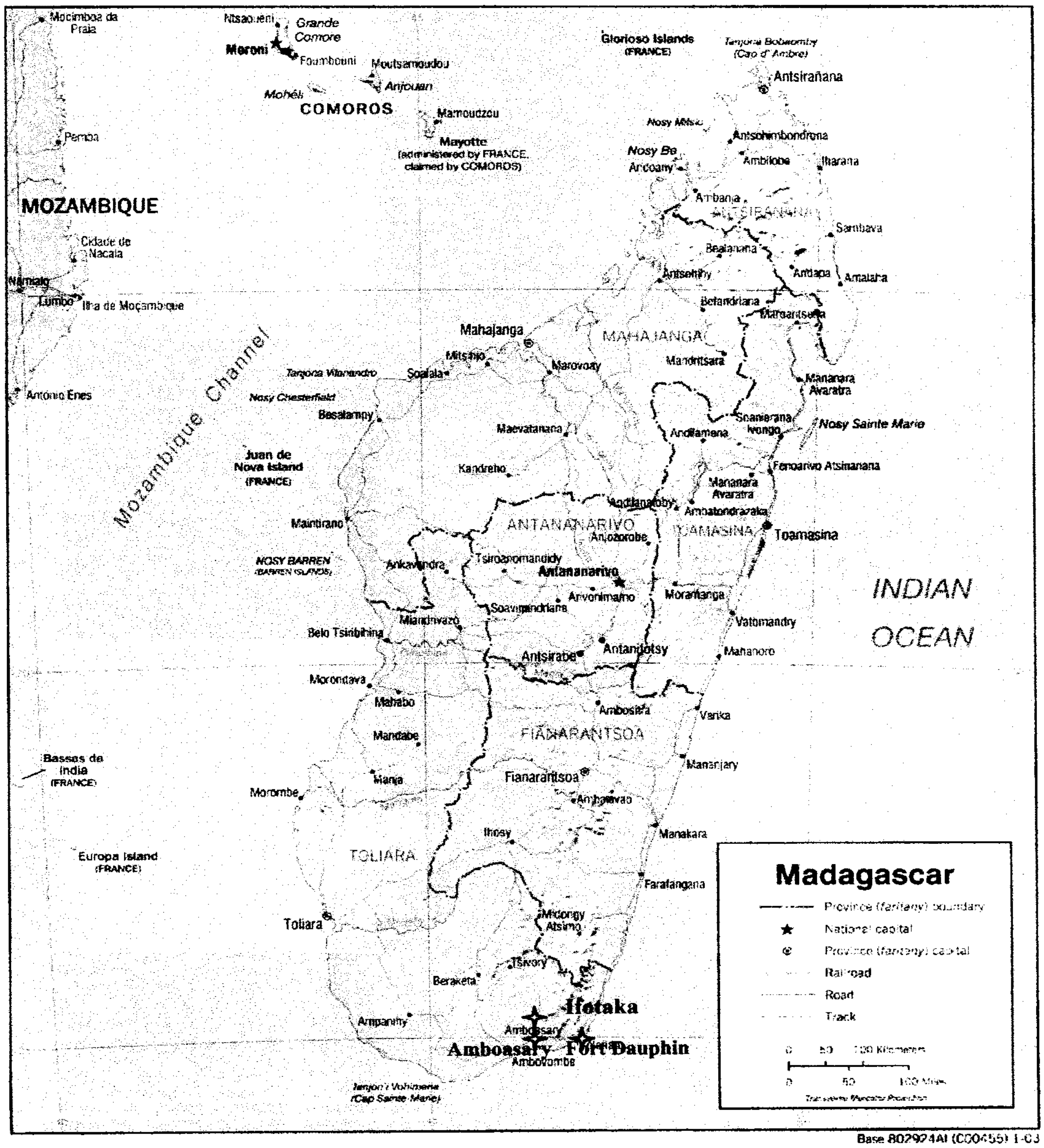
The main study objective was to determine how diet quality affects the number of days spent ill from infectious disease in children under six in a rural area of Southern Madagascar. The hypothesis is that an increase in diet quality leads to an improvement in health. This study also aimed to identify forest resources used regularly by the Antandroy to supplement their diet.

Methods

Description of the Study Sites

The study took place from September to mid- December 2004. There were three separate sites for this study, each a separate village. All the villages were in an arid climatic zone within the Province of Toliara in Southern Madagascar. All the sites were about 20kms north of the town Amboasary and in close proximity to the spiny forest. All inhabitants were of the same ethnic group, the Antandroy (alternative pronunciation: Tandroy) and spoke the Tandroy dialect of Malagasy. The key towns and villages can be located on the map of Madagascar in Figure 1. The elevation of all three sites is about 10m and the latitude and longitude of Ifotaka village is 24S, 46E. Ifotaka was the main site as it was the largest village with a population of 600. The second largest village, Amboetse, had approximately 90 inhabitants and Morafeno, the smallest village, had approximately 40 inhabitants. In the analysis, the villages of Amboetse and Morafeno were grouped together as they shared many characteristics such as remoteness of access, absence of latrines and clean water, lack of medical and educational facilities and distance from markets, that differed from Ifotaka.

Figure 1: A map showing Madagascar and the position of Ifotaka, Fort Dauphin and Amboasary.



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Food avaliability in Ifotaka

This study was carried out in a village in the South of Madagasar in a hot, arid climate zone. All the members of this community are cultivaters. The main sources of carbohydrate are manioc, sweet potato and maize. Manioc and sweet potato are dried and are available throughout the year. Maize is eaten only around the time that it is available for harvest in March. The leaves of sweet potato and manioc are also a regular part of the diet. Other crops cultivated in this region and consumed when available are spring onions, tomatoes and pumpkins, of which the gourd and the leaves are consumed. Pulses are also cultivated and dried to be consumed throughout the year. On average, the rural population of the South consumes 1869 calories daily (Dostie *et al.*, 2002[5]). This is below the threshold of 2133 required to support a productive and normal life. (Dostie *et al.*, 2002).

The weather in this region remains hot and dry with very little rain for 10 months of the year. The rainy season is in November and December although rain during this time is in short bursts and much of the rain water evapourates or runs off the earth, having little impact on the water table of the ground. Because of this harsh climate, food is often scarce and there is little variability in the diet of the people of this region.

By preference, the people of this communtity would consume rice every day and this is imported into the region. Per capita, Madagascar consumes more

[5] Using calculations from the Enquete Permanante Aupres des Menages 1993/1994, Conducted by the National Institute of Statistics for Madagascar (INSTAT).

rice than any other country in Africa[6]. Madagascar cannot produce enough rice to meet the domestic demand and supplements it's need through imports mainly from India and Pakistan. Rice is not cutivated in Ifotaka but is available to members of this community from market traders and it is given out in return for work on maintaining roads in a project run by the World Food Programme. This employment is rotated through all adults in the community during the lean season.

Seasonality is an important determinant of food security in the rural South of Madagascar. Prices in all foods rise sharply during the lean season and rice is priced out of reach for the majority of the rural poor. Dostie *et al.* (2002) estimate that in poor rural household in the South of Madagascar, calorie intake decreases by 9.5% during this season.

Cattleherding and that of other domestic animals such as sheep and goats, is an important activity to the people of this community. These animals however, and in particular the cattle, are not viewed as a source of nutrition by the community but as a indication of wealth and social status. Cattle are never killed directly for food but after a sacrifice of cattle marking an important event, the meat is shared out to all members of the community and eaten. Chickens are kept but eggs are scarce. Many members of the community have taboos which prevent them from eating certain meats. For all members of the community pork is forbidden and for many people chicken and eggs are taboo foods.

There is a daily market in Ifotaka where people can sell the surplus from their fields. There are two weekly markets within walking distance from Ifotaka

[6] From the statistics division of the FAO (Food and Agriculture Organisation of the United Nations) FAOSTAT. Accessed online at http://faostat.fao.org/

where people from a wider area sell surplus cultivated produce and livestock. A diverse range of food items including fruits, vegetables and fish is available at the sea-port town of Fort Dauphin. The ride on public transport to this town, however, is expensive and perishable food items may only last a day upon returing to Ifotaka.

A final source of food for the people of this region is the vast area of forest neighbouring Ifotaka to the North. It is a source of meat from wild birds and fish can be found in the river depending on the season. Lemurs and tortoises are abundant in the forest but it is taboo for people in Ifotaka to eat these animals. Wild plants from the forest are a widely used resource in Ifotaka. The forest has a high level of endemism and is dominated by species of Euphorbiaceae and Rubaceae as well as being the major habitat for all the members of the Didieraceae or octopus trees. These plants are widely used for medicinal purposes.

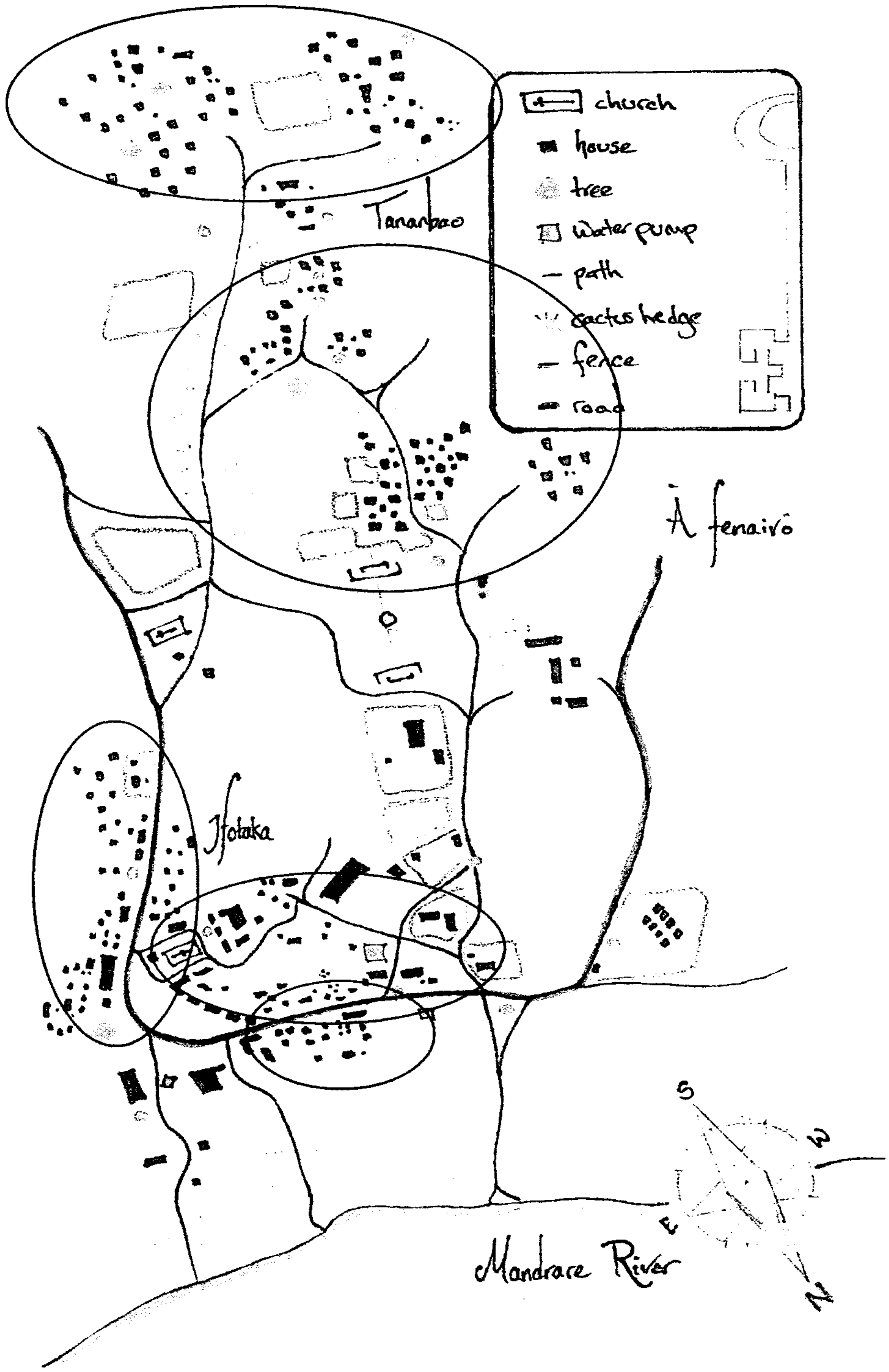
A study in 2001 that interviewed of 6 traditional healers using unstructured interviews lasting between 3-4 days, found over 200 plants known by these healers with stated healing properties for a wide range of ailments such as coughs, intestinal disorders, skin problems and childbirth complicatons (Wilson N, 2002). To date none of these plants have been studied for pharmaceutical properties, however the xerophytic nature of these plants suggests the possibility that many contain bioactive compounds.

Participants

Oral interviews with each participant of the study were conducted using structured questionnaires with the aid of a translator. Inclusion criteria for the study were that the participants had to be female, live in the study area and have at least one child aged below 6 who was no longer breast-fed at the time of interview. The participants were randomly selected from the village of Ifotaka (estimated population 600) using an approximate sketch of the village drawn up by the researcher. Ifotaka includes two areas, Tananbao and Ifotaka Centrale. All members of Ifotaka Centrale and Tananbao have access to the same health care services, school, cultivation areas, water source and food markets. People living in Tanabao and Ifotaka Centrale consider themselves as belonging to one village and for this reason they are considered part of the same village, called Ifotaka in this report. The layout of Ifotaka is represented in figure 2. Not all the houses are shown on the sketch.

For purposes of sampling, the sketch was divided into five arbitrarily chosen areas each comprising approximately the same number of dwellings. These areas were coded IT1-IT5. The household to be approached was chosen by randomly selecting an area using scraps of paper drawn from a bag, and then blindly choosing a point on a rough sketch of that area. The corresponding dwelling was then found using the sketched map as a guide. The mother of the household was approached, the study objectives were explained and the statement of consent was read to her. Participation was voluntary and oral consent was obtained from all participants in the presence of the translator. If a house was approached and the person to be approached was not at home, a repeat visit was made later the same day.

Figure 2: Sketch of the village of Ifotaka showing the different selection areas



The Questionnaires

An initial food list was constructed by making an inventory of all the food items available at the local market of Fenaivo. Fenaivo is a weekly market 2 hours walk from Ifotaka. It is a meeting place for the people of Ifotaka and surrounding villages who meet to buy and sell produce from their fields as well as livestock. Fenaivo was selected as the largest market attracting people from the widest area and therefore having the greatest number of the available food items. The food list was supplemented with other items through three interviews with key informants and one focus group in Tananbao containing women and men. These supplemented food items were either cultivated but not sold or found wild and included wild plants used in teas. The food list was translated into the Tandroy dialect as with all questionnaires in this study. It was made clear at the start of each interview that responses and participation was voluntary.

The completed food list was read out to each participant who indicated for each item whether the child had consumed this item in the last 7 days. At the end of the list, the mother was asked whether her child had eaten any additional items not found on the list and in particular any teas, and if these had been given for a specific health purpose. The dietary diversity questionnaire with the complete food list is reproduced in Appendix A.

Another questionnaire concerning the history of disease in the child during the past month and the number of vaccines the child had received was given to each participant. This, as well as a questionnaire relating to household makeup and livelihood of the family, was administered to each participant. These last questionnaires can be seen in appendix B. All the interviews were conducted in as private a setting as possible to avoid embarrassment or unease by the participant in the presence of neighbours.

The first 16 interviews in Ifotaka village were conducted over a period of 3 weeks. An overview of the results from these 16 led to modifications of the questionnaires to streamline the interviews and optimize the coherence of the questions by the study population. Opportunity then arose to conduct interviews in the village of Amboetse where 20 further interviews were conducted and in the village of Morafeno where 8 more interviews were conducted. The remaining time was spent in Ifotaka collecting 33 more interviews. The total number of participants in Ifotaka was 49.

Statistical Procedures

The consumption characteristics of the population were calculated by taking the mean food variety score for the population at each of the study sites. The mean number of food groups for each site and the mean number of items consumed within certain food groups was also calculated for each site. A t-test was used to calculate differences in these measures between the sites. These are shown in table 1. The socio-economic characteristics are presented as the number of people with each listed characteristic and the percentage of the total population of that site. These are presented in table 2.

The data were analysed using the SAS system version 8.0 (SAS, Carey, NC). The logistic procedure was used to fit a proportional odds regression model.

Number of days ill was the dependant variable and was considered as an ordinal polytomous response according to nomenclature used in Stokes *et al.* (2000). The dependant variable was divided into 5 categories: 0 days ill, 1-3 days ill, 4-6 days ill, 7 days ill and >7 days ill. This was done because the data fit neither a normal nor poisson distribution. The potential inaccuracy of the responses to the question, "how many days did this child spend ill during the past month?" was felt to merit this grouping of responses. Seven days is equal to one week, which could be a convenient approximation of the actual number of days. Responses for more than one week were often given with a measure of uncertainty. For this reason, it is considered reasonable to group them into one group. Reponses of one to six days were grouped in 1-3 and 4-6 days and this ensured large enough numbers within each group.

The non-dietary variables recorded were: age of child, sex of child, marital status of the mother, number of children in the family, access to latrines, presence of electric lights in the household, whether or not the child had childhood vaccinations, presence of a regular income by a care giver, whether the mother attended secondary school and the religion of the mother. The dietary variables were: total food item diversity alone and the diversity among and within various food groups. The food item diversity score was the total number of food items consumed from the food list. The food group diversity score was the number of different food groups consumed by the child. The logistic procedure selected variables using a stepwise selection with the entry threshold set at 0.2 and the threshold for staying in the model at 0.25.

Pearson's correlations were calculated for correlations between various non-dietary variables. Simple linear regression models were used to find how various socio-economic variables were associated with the consumption of different food groups. All measures were considered significant when $p<0.05$.

Results

Forty-nine people in Ifotaka were interviewed in this study. Twenty people were interviewed in Amboetse and there were 8 participants in Morafeno. Two out of a total 79 people, both from Ifotaka, declined to participate due to lack of interest, giving an overall response rate of 97.5%. All the women who were approached in Amboetse and Morafeno agreed to participate in this study.

The study Population

Table 1: Consumption characteristics of the study populations.

	Ifotaka (n=49)	Amboetse + Morafeno (n=28)	Total (n=77)
Diet summary			
Food item variety (mean±SD)[1]	25.33 ± 6.81	25.71 ± 9.14	25.47 ± 7.68
Food groups (max = 13) (mean±SD)[1]	10.29 ± 1.62	10.18 ± 1.79	10.25 ± 1.67
Cultivated plants (mean±SD)[1]	12.31 ± 2.78	12.07 ± 3.55	12.22 ± 3.06
Collected plants (mean±SD)[1]	1.12 ± 0.81	1.39 ± 2.03	1.22 ± 1.38
Domesticated meat (mean±SD)[1]	1.47 ± 0.94	1.75 ± 1.27	1.57 ± 1.07
Wild meat (mean±SD)[1]	1.14 ± 1.21	2.36 ± 1.99 *	1.58 ± 1.63
Food bought at local market (mean±SD)[1]	5.88 ± 2.56	5.75 ± 2.30	5.83 ± 2.46
Food bought at nearest city (mean±SD)[1]	0.31 ± 0.55	0.14 ± 0.36	0.25 ± 0.49

[1] The mean and standard deviation of the number of food items consumed per child per week.

* Where Amboetse and Morafeno are significantly different from Ifotaka values p=0.0013

Table 2: Health and socio-economic indicators of the study population.

	Ifotaka (n=49)		Amboetse + Morafeno (n=28)		Total (n=77)	
Child	n	%	n	%	n	%
Age in years (mean±SD)	3.51 ± 1.16		3.64 ± 1.19		3.56 ± 1.16	
Female	26	53	12	43	38	49
Vaccinated	41	84	3	11	44	57
Not ill	14	29	3	11	17	22
1-3 days ill	7	14	6	21	13	17
4-6 days ill	9	18	2	7	11	14
7 days ill	9	18	7	25	16	21
>7 days ill	10	20	10	36	20	26

Mother

Number of children (mean±SD)	4.53 ± 2.49		Not determined	
	n	%		
Attended secondary school	14	29	Not determined	
Not married	8	16	Not determined	
Christian	37	76	Not determined	

Household

Regular monetary income	5	10	Not determined		
Access to latrines	19	39	0	19	25
Electric lights in the house	10	20	0	10	13

Table 3: **Infection and treatment type of children who were ill in the past month.**

	Ifotaka (n=49)		Amboetse + Morafeno (n=28)		Total (n=77)	
Infection type	n	%	n	%	n	%
Diarrhoea	13	37	8	32	17	28
Cough	10	29	13	53	23	38
Fever	12	34	6	24	17	28
Treatment type	n	%	n	%	n	%
Medicine	28	80	19	76	47	78
Plants	5	14	9	36	14	23
Consult a doctor	11	31	2	8	13	22
Hot hands	3	9	6	24	9	15
None	3	9	2	8	5	8

Incomplete household questionnaires were administered in the villages of Amboetse and Morafeno. In these villages, the household questionnaire did not contain all the questions that the Ifotaka questionnaire did. Questions about the education and religion of the mother were excluded because of difficulty in these places in maintaining the anonymity of the participant. Because of the differences between Ifotaka and the other sites, the data from Ifotaka shall first be considered alone.

Of those women in Ifotaka included in the study, 65% (n=32) were exclusively cultivators, producing only enough food to feed their families and seldom with extra food to sell at a market. Sixteen percent (n=8) made a small income through selling their agricultural produce or weaved mats at a market on a monthly, or more frequent, basis. Six percent (n=3) had a profession as either a teacher or a nurse. Although the salary of the participants was not asked, one of the informants, who was a teacher, informed the interviewer that she did not earn a salary but worked for free. The group with the highest economic status in Ifotaka are the shopkeepers and to a lesser extent the coffee sellers. Ten percent (n=5) of the population fall into this category, and it is these five that are classified as having a Regular Household Income. Four out of the five shopkeepers had access to electricity and all shopkeepers had access to a long-drop latrine. This and other co-occurrences of socio-economic variables are shown in Table 4

Table 4: Significant correlations between social and economic variables for Ifotaka (n=49).

Pearson's correlations			
First variable	**Second variable**	**Coefficient**	**p-value**
regular income	latrine	0.424	0.0024
regular income	electric lights	0.498	0.0003
regular income	children	0.419	0.0027
latrine	electric lights	0.532	<0.0001
latrine	secondary school	0.424	0.0024
secondary school	marital status	-0.332	0.0199
electric lights	attends church	0.288	0.0445
secondary school	attends church	0.360	0.0110

A Diet Summary

A summary of the composition of the diet in Ifotaka is shown in Table 5. People in Ifotaka consumed a total of 101 different food items. Foods consumed by 10% or more of the study population are included with the percentage of children reported to have consumed each item.

Table 5: A summary of the composition of the diet at Ifotaka (n=49).

Food group	Food group use (%)	Total foods in group	Mean number foods consumed	Items consumed by >10% of the participants	% participants consuming each item
Cereals	88	6	2.2	Rice	67
				Maize dumplings	67
				Maize	43
				Rice dumplings	20
				Packaged noodles	14
Roots/Tubers	100	6	2.1	Manioc	96
				Sweet potato	96
				Dolichos fangitsa	16
Legumes	100	6	2.4	*Dolichos lablab*	90
				Peanuts	61
				Red beans	41
				White beans	27
				Cowpea	18
Green Leaves	98	6	3	Pumpkin leaves	88

				Sweet potato leaves	80
				Manioc leaves	71
				Spilanthes acmella	51
Vegetables	98	6	3.1	Tomato	94
				Spring onion	84
				Pumpkin	67
				Garlic	49
				Onion	12
Meat	86	8	1.7	Goat	69
				Chicken	39
				Beef	37
Fish	63	9	0.9	*Fiampoty*+	24
				Toho+	22
				Ptychochromis sp	14
Milk	53	3	0.6	–	53
Eggs	37	1	0.4	–	37
Fruit	94	3	1.6	Mango	94
				Tamarind	71
Oil/Sugar	98	7	3.4	Vegetable oil	86
				Butter biscuits	72

				Sugar	69
				Sugar cane	65
				Sweets	49
				Honey	33
Wild Teas	16	7	0.2	No single item consumed >10%	
Other	96	5	1.8	Salt	96
				Coffee	41
				Curry powder	24
				Pepper	16

[+] Where the species could not be identified, local names are used.

Manioc and sweet potato are the staple carbohydrates of this diet. Also eaten widely are legumes of which *Dolichos lablab,* the hyacinth bean, is the most common in the diet. Green leaves are eaten by 98% of the population. One of these is *Spilanthes acmella* (*Chakamafana* in Antandroy dialect). This herb is added to the leaves of manioc, sweet potato and pumpkin for its hot, spicy flavour. It is cultivated in the fields around Ifotaka. This plant is used as a treatment for toothache in some parts of the world and at least one study has suggested that this plant has anti-inflammatory properties (Chakraborty *et al.*, 2004).

Among the wild plants, *Dolichos fangitsa* is a vine that grows a tuber at its base. These tubers, which are eaten raw and have a watery consistency, are consumed when they are found in the forest and used to stimulate the appetite.

Tamarind seeds (*Tamarindus indica*) are also consumed regularly. They are not cultivated but the trees grow in and around Ifotaka village for shade. Similarly the *Opuntia sp.* cactus grows in and around the village and used as a natural fence. The fruits, prickly pears, are eaten when they are in season.

Wild plants are also prepared as infusions to be drunk. These preparations are made from one plant rather than a mixture of plants. The survey aimed to include all these preparations whether they were consumed over the short-term as treatment for a specific ailment, or daily, for taste or for general health. All teas made from wild plants consumed in the period under study are included in the dietary survey. There were 7 different wild plants used to make tea by people in Ifotaka. No single plant was used for this purpose by more than 10% of the population.

A list of all the plant species recorded in the dietary surveys from all three villages is shown in Appendix C. The number of times each plant was mentioned by a respondent for a particular use is recorded. The plants recorded as being used to treat infectious diseases are only those that were consumed for this purpose during the seven days of the dietary survey. They are listed in order of those mentioned by the most number of respondents to those mentioned the least number of times. Scientific names of some of the plants could not be found as there was no expert available to identify them in the field. There were a total of 57 plants named by mothers in this survey.

Eighty-six percent of the population of Ifotaka ate meat at least once a week. As well as domesticated meat, wild meats such as birds, freshwater fish and tenrecs[7] were consumed by 65% of the participants. Four species of wild bird appeared on the dietary questionnaire and 14% had eaten at least one of these in the past 7 days. There were 8 species of fish and 63% of the study population had eaten at least one fish species.

Effect of Diet on Days Ill

Multivariate logistic regression models were run with social and economic variables included with dietary variables to determine the effect of these on the number of Days Spent Ill in children. In order not to over-parameterize the model, correlations between these social and economic variables were considered. Those that showed a significant correlation are shown in Table 4.

The variables chosen to be included in the analyses were Regular Household Income and Mother Attended Secondary School as both correlate well various other factors. Access to Latrines and Presence of Electric Lights were also included in the models because, from field observations, they were deemed reliable measures of socio-economic status. Also included in the model were the variables Sex of the Child, Age of the Child and Possession of Childhood Vaccinations, also of the child.

Food Variety

The number of food items consumed over 7 days (food variety) ranged from 8 to 33. This number counts each item in the food list (see appendix A) as a separate food item and includes drinks. The mean value was approximately 25. This food

[7] A small mammal that occupies a similar niche to a hedgehog.

variety was included in a multivariate model and not found to be significant determinant of Days Ill.

Food Group Diversity

The diet was split into food groups chosen with reference to groups used by other researchers. Torheim *et al.* (2003) used 11 food groups when describing a diet in Western Mali: Cereals, Legumes, Oil/sugar, Fruit, Vegetables, Meat, Fish, Eggs, Milk, Green Leaves and Other. In our study, the same food groups were used because of the apparent similarities in the diet composition of Western Mali and Madagascar, but two new categories were added, Roots/Tubers and Wild Teas, bringing the number of food groups used in this study to a total of 13. The Wild Teas food group was added because of the particular interest in relevance of wild plants in this study. The Roots/Tubers group was used to distinguish the staples of the Malagasy diet: sweet potato and manioc.

A logistic regression model with the number of food groups as a variable, rather than the number of food items, was run. As in the case of food variety, this dietary variable was not significant.

Nutritional Groupings

The diet was subsequently broken down into various nutritional groups similar to the different food groups. These were Cereals, Roots/Tubers, Green Leaves, Vegetables, Legumes, Fruit, Wild Teas, Meat/Fish, Eggs, Milk, Oil/Sugar and Other. The number of foods consumed within each of these categories was counted for each individual and a model containing all these groups, as well as the socio-economic measures, was run in order to investigate which food groups, if any, are important in determining Number of Days Ill in children. The Results of the model, after stepwise selection, are shown below.

Table 6: Factors affecting the number of days ill per month for Ifotaka alone (N=49) with diet split by food group

Effect	Log Estimate	Chi-Square	p-value
Meat/Fish	-0.617	9.98	0.0016
Milk	+1.053	4.54	0.0331
Vaccinated	-0.686	2.48	0.1152
Attended Secondary	-0.494	1.85	0.1740

The probabilities are cumulated over the lower values, meaning that the data shown are the result of trying to fit each effect into categories of increasing days ill. In this case, the data can be interpreted as such: an increase in the number of meat products consumed decreases the probability that the individual will have spent a longer time ill. A positive log estimate for Milk implies that those who consumed a large variety of milk products spent more days ill than those who consumed less milk products. The size of the estimate indicates the size of the effect. Milk shows almost twice the effect of meat in determining number of days ill, but the probability that Meat is a true effect is higher than that for Milk as the p-value for Meat is less than that for Milk. Both these dietary variables however are significant at $p<0.05$.

Possession of a full set of childhood vaccinations shows a trend towards less days spent ill as does the Attendance of Secondary School by the mother. These data could equally have been displayed as odds ratio estimates. The odds ratio is equal to $e^{\text{log estimate}}$.

Grouping by Source

The data were then grouped by source: Cultivated Foods, Collected Foods (from the forest), Market Foods (food items bought from vendors in Ifotaka) and foods transported by individuals from the Port of Fort Dauphin. The same social and economic variables as the last analyses were included. The results of the model, after stepwise selection, are shown in Table 7.

Table 7: Factors affecting the number of days ill per month for Ifotaka alone (N=49) with diet split by food source.

Effect	Log estimate	Chi-square	p-value
Cultivated food[a]	+0.152	2.62	0.1057
Collected food[b]	-0.686	10.04	0.0015
Attended secondary school	-0.861	5.57	0.0183
Sex	+0.474	2.56	0.1099

[a] Includes all cultivated plants and domesticated meats, eggs and milk. [b] Includes all wild plants and wild meats (fish and birds).

A positive estimate for Cultivated Foods indicates that a consumption of a greater variety of these foods leads to an increased likelihood of spending more days ill. The effect of cultivated foods shows a trend rather than a probable effect because of the large p-value. Consumption of a larger variety of collected foods appears to decrease the likelihood of spending more days ill. The attendance of secondary school by the mother appears similarly to have a positive effect on the health of the child. The positive estimate for the variable Sex indicates that males spent more time ill than females.

In order to understand more fully the effect of the different dietary components, the food distinctions were split again into plants and animal. The Cultivated Foods were split into all Plants Cultivated in Ifotaka - maize, sweet potato, manioc, green leaves, legumes, mangoes, and vegetables - and Domestic Animal products - beef, goat, chicken, eggs and milk. The Collected Foods were split into Wild Plants and Wild Animals - birds, tenrecs, freshwater fish, crayfish and eels. As in the previous analyses, the other variables in the model were Age, Sex and Possession of Childhood Vaccinations of the child, Attendance of Secondary School by the mother, and Access by the household to Latrines, Electric lights and a Regular Household Income. The results of the regression model are shown in Table 8.

Table 8: Factors affecting the number of days ill per month for Ifotaka alone (N=49) with diet split by plant and animal origin.

Effect	Log estimate	Chi-square	p-value
Cultivated plants	+0.269	4.78	0.0288
Wild plants	-0.570	1.84	0.1754
Wild meat	-0.917	8.86	0.0029
Food bought in Fort Dauphin	-1.204	3.84	0.0500
Attended secondary school	-1.298	7.29	0.0069
Sex	+0.657	4.11	0.0428

The model described in Table 8 builds from the model in Table 7 and indicates that cultivated plants are more important than domestic animal products in having negative effect on days ill and wild meats rather than wild plants have the biggest beneficial effect on health. Wild Plants do show a trend towards having a beneficial effect. There is also a significant effect of foods bought from the Port of Fort Dauphin. These food items were cucumbers, French bread, bananas, custard apples, lemons and potatoes. Access to Fort Dauphin is reserved for those who can afford the bus fare. For some, this is a regular journey to visit relatives; others may never have made the journey. The variables Sex and Attended Secondary School are present in this model as in the last, but are more significant in this model.

Food Consumption in various Socio-Economic groups

In order to complete the picture, the associations between various socio-economic factors and the consumption of food groups was examined. These associations can be seen in Table 9. The only socio-economic variable that divided the population into groups that ate a different diet is the presence of a regular household income. These significant p-values are highlighted in bold.

Table 9: Mean number of food items per child per week among different health and social groups for Ifotaka (N=49).

	Food item variety total number of food items	**Food groups** Total number of food groups (max.=13)	**Meat** (meat - inc. wild birds - and fish	**Milk**	**Wild meats**	**Cultivated foods** All cultivated foods and domestic animals	**Collected foods** All collected plants and wild animals	**Cultivated plants** All plants cultivated in Ifotaka	**Wild Plants** All collected plants and honey	**Fort Dauphin** Foods bought at the Port od Fort Dauphin
Total N=49 Mean (SD)	25.33 (6.81)	10.29 (1.62)	2.61 (1.77)	0.63 (0.67)	1.14 (1.21)	14.73 (3.41)	2.59 (1.88)	12.31 (2.78)	1.12 (0.81)	0.31 (0.55)
Vaccinated (n=41)	25.17	10.22	2.54	0.65	1.02	14.78	2.41	12.22	1.39	0.32
Not vaccinated (n=8)	26.13	10.50	3.00	0.50	1.75	14.50	3.50	12.50	1.75	0.25
p-value	*0.4746*	*0.4225*	*0.7292*	*0.8743*	*0.3561*	*0.798*	*0.2988*	*0.9997*	*0.4426*	*0.5218*
Access to latrines (n=19)	26.74	10.58	2.26	0.63	0.71	14.74	2.16	12.00	1.42	0.58
No access (n=30)	24.43	10.07	2.83	0.63	1.31	14.73	2.87	12.43	1.47	0.13
p-value	*0.6783*	*0.5656*	*0.455*	*0.1842*	*0.4417*	*0.7066*	*0.668*	*0.7299*	*0.8796*	*0.0636*
Electric lights (n=10)	27.30	10.30	2.10	0.70	0.50	14.80	1.70	11.90	1.20	0.60
No Electric lights (n=39)	24.82	10.26	2.74	0.62	1.31	14.72	2.82	12.36	1.51	0.23
p-value	*0.9614*	*0.2322*	*0.3708*	*0.555*	*0.2257*	*0.4573*	*0.1788*	*0.5029*	*0.328*	*0.3671*
Regular income(n=5)	31.20	11.60	3.00	1.40	1.00	17.60	2.60	13.40	1.60	0.40
No regular income (n=44)	24.66	10.11	2.57	0.55	1.16	14.41	2.59	12.14	1.43	0.30
p-value	*0.1105*	***0.044***	*0.1955*	***0.0015***	*0.3397*	***0.03***	*0.2817*	*0.1778*	*0.4252*	*0.3174*
High education (n=14)	25.57	10.50	2.29	0.71	0.71	14.29	2.14	11.64	1.43	0.57
Poor education (n=35)	25.23	10.17	2.74	0.60	1.31	14.91	2.77	12.51	1.46	0.20
p-value	*0.9929*	*0.5277*	*0.9021*	*0.1523*	*0.6038*	*0.694*	*0.8577*	*0.5307*	*0.8037*	*0.2777*

The Villages of Amboetse and Morafeno
Amboetse and Morafeno are more remote than Ifotaka meaning that trips to Fort Dauphin are much less common, and schools and health clinics are much less accessible. Whereas there is a health clinic and three schools in Ifotaka, these do not exist in more remote villages. Likewise, no electricity or latrines was available in eiAmboetse or Morafeno. Most children in Ifotaka (84%) were reported to have received five childhood vaccinations and children in Amboetse had most commonly only received one vaccination (85%). This is a result of the remoteness of Amboetse.

The staples of the diet remained the same between the sites but Amboetse and Morafeno consumed significantly more wild meat ($p<0.01$) (see table 1). Although there is no statistical difference, wild plant use seemed more common in Amboetse and Morafeno compared to Ifotaka. One of these wild plants, eaten by children in Morafeno, is *Jabihy* berries (*Strychnos sp.*), which have a large stone and grow on a tree with a bulbous base. The berries are available only at the beginning of the wet season and are also a favourite food of lemurs.

In light of the results of the data from Ifotaka alone, all 77 observations were analysed with the dietary variables split into the same divisions as for Ifotaka alone. The variables Regular Household Income and Attendance of Secondary School by the mother could not be included because, as discussed above, the relevant data were not collected from the villages of Amboetse and Morafeno. An effect of Site (i.e. Ifotaka=1, Amboetse=2 and Morafeno=3) was included in this model.

Table 10: Factors affecting the number of days ill per month for all sites (N=77) with diet split by food group.

Effect	Log estimate	Chi-Square	p-value
Cereals	-0.991	7.64	0.0057
Vegetables	+0.664	5.90	0.0151
Meat/Fish	-0.563	16.56	<0.0001
Milk	+1.238	8.61	0.0033
Site1	-1.778	9.72	0.0018
Site2	+0.798	2.97	0.0850
Age	-0.691	10.20	0.0014
Vaccinations	-1.074	1.92	0.0061
Electric lights	-0.565	7.53	0.1659

The effects Site1 and Site 2 are deviations from Site 3. The effect of Site was significant determinant of Days Ill with there being a large and significant increase in time spent ill between in Morafeno compared to Ifotaka ($p<0.01$). There was no significant difference in Days Ill between Morafeno and Amboetse. Like in the analysis of data from Ifotaka alone, meat, milk and possession of childhood vaccinations are determinants of days ill. Also in this model a beneficial effect of cereals (rice, maize, noodles and french bread) and a detrimental effect of vegetables was observed Older children spend less time ill than younger children and there is a trend suggesting that possession of electric light in the households is a predictor of less days ill.

Table 11: Factors affecting the number of days ill per month for all sites (N=77) with diet split by plant and animal origin.

Effect	Log Estimate	Chi Square	p-value
Cultivated plants	+0.122	2.25	0.1178
Wild Meats	-0.489	8.26	0.0041
Site 1	-1.457	7.74	0.0054
Site 2	+0.318	0.63	0.4256
Age	-0.445	5.07	0.0244
Vaccinations	-1.242	10.98	0.0009

Results from the analysis of data from Ifotaka only in table 8, agree with the model in Table 11. Cultivated plants have a detrimental effect and wild meats have a beneficial effect. Ifotaka differs from Morafeno while Morfeno and Amboetse are not different in time spent ill in children. The probability of spending more days ill decreases with increasing age and possession of childhood vaccinations decreases the likelihood of spending more days ill.

Teas for infants and pregnant women

Half way through the study the interviews were extended to ask if the mother knew of any plants that were good for the health of infants, children, adults, pregnant or lactating women or old people. Many women were knowledgeable about the use of plants for infants and for women while pregnant.

Seven out of 33 people (21.2%) in Ifotaka and 16 out of 20 people (80.0%) in Amboetse responded 'Yes' when asked if they gave plants to infants. These people were able to give the name, preparation method, time of administration and reason of administration of plants they had used. The plants were typically brewed into tea and given along with breast milk every day. For the first 6 months of life, infants are given a different tea each month. The practice stops after 6 months. Breastfeeding continues after 6 months and solid foods are introduced.

The most common reason for giving each plant was 'To cleanse the stomach of the newborn'. The Antandroy require that impurities in the child's stomach that are acquired from the mother, be washed from the child in order for the child to be healthy. This practice is discouraged by local health workers.

A logistic regression model was run to test if there is a difference in days ill between those who gave their children infusions as infants and those who did not. Feeding plants to infants showed no significant effect. From our data however, a correlation between childhood vaccinations and whether plants were administered as a child gives a coefficient of -0.4213 with a p-value of 0.0017. It appears that infant teas are often given in the place of conventional vaccines. Appendix C gives a summary of all the wild plants and their uses. See Appendix C for a list of plants fed to infants.

Discussion

Food Variety and Food Group Diversity

The number of different food items does not affect the number of days ill from infection in this study and neither does the number of food groups consumed. The hypothesis that greater food variety and food group diversity results in less day spent ill is not upheld. From the percentage of respondents that consumed from each food group (Table 5), it is evident that a high proportion of people consumed at least one item from each group. The small range in this variable may be why an analysis does not find this variable significant. Because of the high dependence on a few staples such as the roots and leaves of manioc and sweet potato, the food diversity score may not be powerful enough to identify those people who ate more wild foods and other such foods that are the strongest predictors of health. These groups became apparent when the diet was analysed by the variety within groups of food.

The effect of Meat

When the diet was grouped by nutritional categories, meat consumption was a strong predictor of days ill. An increase in the variety of meat consumed led to fewer days spent ill in the children in the study. Table 9 shows that there was no significant difference in the number of total meat products eaten between those with a regular household income and those without. This leaves three possible explanations for the significant beneficial effect of meat on health found from this analysis. Meat diversity could correlate to a high degree with some unmeasured economic variable. In this case, the economic superiority of the group of high meat consumers could be the true cause of the lower illness rate observed in these children. Alternatively, the measure of food diversity, rather than quantity, is not sufficiently robust to predict health status and the effect of meat is a statistical anomaly and not a true effect. Finally, an explanation that involves the nutritional benefit of consuming more meat could be found to explain how more meat gives rise to less days ill in children.

In reference to this last option, meat contains important quantities of protein, fat, iron, zinc and fat soluble vitamins. A diet containing adequate quantities of meat protects people from nutrient deficiencies in a setting such as rural Africa, and can also increase the bioavailability of micronutrients from plant foods (Gibson & Hotz, 2001). Non-heme iron absorption in humans can be increased by 220% by eating beef, 140% by chicken meat and 75% by eating fish (Cook & Monsen, 1976).

The subsequent analysis in the model that divided meats into wild and domestic (Table 6 and Table 9) shows that wild meats, which included fish, wild birds and tenrecs, was a highly significant predictor of Days Ill whereas domesticated meats were not. A high meat variety score may indeed be a reflection of elevated socio-economic status. Meat is an expensive commodity and therefore, eaten more frequently by those who have the economic means. This is true in theory only of the cultivated meats - beef, chicken and goat – that had no effect on days ill. The perceived value of consuming domestic meats is high. Because of this, the consumption of these meats as recorded by the questionnaire may be exaggerated compared to the true level of consumption. In informal discussions with various members of the community, most reported that they ate meat once a month or less, whereas in this survey 86% said that they'd consumed it in the past week.

The Effect of Milk

The food group Milk consisted of three food items: cow's milk, goat's milk and curdled cow's milk. From Table 7 it is evident that those households with a regular income have on average a higher consumption of milk than those households without a regular income. The detrimental effect of milk cannot, therefore, be explained by people of lower socio-economic status consuming, for one reason or another, more milk. This effect is contrary to expectations as milk is an important source of calcium and protein.

One explanation is that milk is not pasteurised and may be stored in unsanitary conditions. Milk is an ideal medium for the growth of bacteria, fungi and other organisms which cause diseases in such as salmonellosis and tuberculosis (Potter *et* al., 1984). Heating the milk or sterile storage conditions are necessary to ensure that fresh milk is safe. If indeed milk does pose a health risk to children who drink more of it, education programmes in the area should look into seminars about the safe preparation and storage of fresh milk.

The Effect of Cultivated Foods

The diversity of cultivated plants including all cereals, tubers, legumes and green leaves is leads to more days spent ill in children in this study. This is not what we would expect from based on the knowledge that green leaves, legumes and cereals are rich in micronutrients and active phytochemicals. It is true, however, that not all phytochemicals are beneficial. Legumes, cereals and green leaves are high in phytic acid and polyphenols that inhibit intestinal absorption of minerals such as zinc and iron (Gibson & Hotz, 2001).

The negative effect of cultivated plant diversity (and the negative effect of vegetables in the analysis of observations from all sites) on illness may be explained if plants take the place of meat in the diet. In this case it would not be the high number of plants eaten but the lack of meat, that leads to more days spent ill in these subjects.

In a study of a food frequency questionnaire that used cross-checking questions to assess reporting of various food groups, it was found that vegetables, and the related nutrients including vitamin A, were particularly difficult to assess (Calvert *et al.*, 1997). This may be because vegetables that are part of sauces or mixed dishes are sometimes forgotten. If, in the present study, there is a lack of accuracy in the reporting of vegetables, the results for this food group would be unreliable. Another reason for a food being mis-reported, as in the case of domestic meat, is social desirability bias.

Food imported from Fort Dauphin has a significant beneficial effect on health. These foods are a group of 5 fruits and vegetables and French baguette bread. Extra fruits and vegetables would be expected to improve nutritional status and therefore health. The difficulty of obtaining these foods means that they are necessarily associated with families that have the means to obtain them.

The Effect of Collected Foods

Overall, a high number of collected foods conveyed a beneficial effect on days ill. Wild meats, in particular, had a very strong beneficial effect on the number of days ill in the child. There was no significant difference between the numbers of wild meats consumed by those of high and low economic status (Table 9). Another explanation, therefore, must be found to account for the effect of wild meats.

The effect could be explained in terms of nutrients found in these products. In other populations, wild meat and fish are the main source of protein. Asibey (1974) highlights the importance of wildlife as a source of protein in Sub-Saharan Africa and estimates that 75% of people in this region rely heavily on wild sources of protein. Wild meats account for 88% of dietary protein in the Yassa population of Cameroon (Koppert *et al.*, 1993). Assuming that domestic meats are over-reported, wild meats could be equally important to the population in Ifotaka. Interestingly, an investigation into similar populations also in Cameroon found that despite eating relatively large quantities of meat from wild sources, anaemia was not rare. This was explained by the high burden of intestinal parasites and other diseases in the population (Froment *et al.*, 1993). Apparently, adequate protein in the above population is not sufficient on its own to prevent wide spread infections. For another nutrient based explanation, the fish component of the Wild Meats category could be considered. Fish contain long-chain poly-unsaturated fatty acids, which are known to help prevent chronic disease in a healthy North American population. In terms of immunity to infectious diseases, the fish oil docosahexanoic acid, actually decreased T-cell activation in a study on 42 North American subjects (Kew *et al.*, 2004).

The beneficial effects of wild meats may perhaps not be explained simply in terms of nutritional composition. The collection of wild meats is often done by children. Small birds are taken from nests or hunted using catapults. The game is found in the forest where wild plants are also found. Mothers responding to the dietary questionnaire may be unaware of snacks from wild plants taken while in the forest. Children who bring wild game back to the household for consumption may, therefore, be consuming a much larger diversity of wild plants than could be recorded using this type of survey. The consumption of wild plants by children is known in other populations. Pagezy, (1993) reports on the importance of wild resources in the diet of children in a flooded tropical forest in Zaire and observes that children gather and consume wild fruits during the dry season. Observations in the study in Tanzania by Fleuret (1979) found that fruit consumption by children between 6 months and 14 years was higher than was recorded using dietary recall methods. In this study the questionnaire focussed on what was eaten during meal times and fruits, normally eaten as snacks, were not included (Cunningham, 2001). In another study by Fleuret (1986), an attempt was made to focus on wild fruit consumption in children. Complete dietary intakes over 7 days and in 3 seasons were recorded for 25 children between the ages of 3 and 17, all from Taita communities in Kenya. The survey found that the children consumed 97 species of fruit, 77 wild and 20 cultivated. These fruits clearly are an important part of the child's diet. A similar investigation in Ifotaka, focussing on older children who would be able to self report their diet and carried out while hunting or tending cattle in the forest, would be needed to establish whether a similar dietary pattern of wild food intake existed among the children in Ifotaka.

Wild plants do appear to show a trend towards having a positive effect – that is, in reducing the number of days ill ($p=0.1754$, see Table 8). However, if it is the case that wild plants play a more significant role in immunity and infection than is suggested by this study, the potential for wild plants to have this effect should be considered. In the wild fruits documented in the study by Fleuret (1986), those with nutrient composition data contain important quantities of carotene, vitamin C, calcium, phosphorous and niacin. Alternatively, the beneficial effect on illness of consuming these plants may indeed be due to bioactive chemicals in the plants that boost the immune system or fight infection. More studies into the composition of these plants are required to ascertain whether any such chemicals are present.

The poor representation of wild plants in the Tandroy diet as recorded in this survey may not only be due to children consuming wild plants without their mother's knowledge. There is quite probably reluctance on the part of the respondents to display a wide knowledge of wild plants. As Kuhnlein (2000) explains, leaning about plants with perceived medicinal value from indigenous peoples may difficult for an outside researcher. Beliefs relating to medicinal plant use and the potential economic value of medicinal plants might make people reluctant to impart knowledge about them. In conducting ethno-botanical research into medicinal plants in Madagascar, Randrianerivelojosia *et al.* (2003) recognised an attitude of suspicion of foreigners among traditional healers when they were asked about their knowledge of plants.

Poverty

The inhabitants of Ifotaka and its surroundings are exposed to many risk factors, other than dietary diversity, that would affect malnutrition and the incidence of disease in children. In a study in Indonesia on low height-for-age (stunting) in Indonesia, researchers found that stunting cannot be improved by only one measure of poverty such as income (Gross *et al.*, 1996). Any approach to improve nutritional status must combine many factors. Access to latrines, clean water, health care facilities and education are examples of these other factors. Access to these basic requirements is restricted by the wide-ranging poverty in Ifotaka and Madagascar as a country.

This study did not include the income level of the respondents but economic level of the respondents can be approximated by other indicators. These are the employment of the mother, the presence of electricity in the house and the education level of the mother. A study in Cameroon that looked at the health of rural children identified use of latrines, antimalarial prophylaxis, oral rehydration and vaccinations as factors more important than diet in determining the prevalence of disease in children (Froment, 1993). The diet in this study was deemed to be sufficient in all essential components, but despite this the disease rate was high. In a Co-twin study on the acquisition of the intestinal pathogen *Helicobacter pylori*, researchers found that socio-economic status was a powerful predictor of infection from this bacterium (Malaty *et al.*, 1998).

Socio-economic status and other poverty determinants also affect diet. A study on the socio-economic determinants of food variety on older people in Botswana found that ownership of cattle, an indicator of household wealth, and education were important predictors of food variety. (Clausen *et al.*, 2005). The data from Ifotaka identify these two variables as being important in predicting child health. A study in Uganda found that the most important predictors of stunting in children were: the age of the child, poor health, prolonged breastfeeding, low socio-economic status, education of the mother, lack of paraffin as fuel, consumption of food of low energy density and presence of eye pathology (Kikafunda *et al.*, 1998). The present study could have been improved by widening the scope of variables that may contribute to health in children.

Sanitation

In families that reported no access to a long drop latrine, faeces were left uncovered in areas around the village, often less than 20m from homes. This is poses an obvious risk of spreading infectious disease vectors and parasites. Access to long drop latrines is associated with having a regular household income (Pearson's Correlation coefficient=0.424; $p<0.01$; See table 4). This could be because the amount of land owned by families with a higher income means that they are able to build a facility on their land. Yet land, labour and materials are available to build latrines for the whole community at little or no cost and it is possibly a lack of knowledge of the importance of sanitation and hygiene that is the main barrier to latrine access in Ifotaka. This supposition is supported by the observation that access to long drop toilets is more prevalent in households where the women are educated (Pearson's correlation coefficient=0.424, $p<0.01$; See table 4). In the villages of Amboetse and Morafeno, there is no school and there are also no long-drop latrines.

Fresh water is available to all inhabitants of Ifotaka through three pumps in the village that pump ground water. In Amboetse, water is drunk straight out of the river, and in Morafeno, a spring provides enough water for drinking and cooking. The water source is another difference inherent in the variable 'Site' along with access to healthcare and education.

Education of the Mother

Data from over 35 health surveys indicate that children of mothers with no education have twice the mortality rate and likelihood of being malnourished than children whose mothers with a secondary education (UNICEF, 2001). Education level of the mother is an indication of how well informed they are about the cycle of disease and the importance of hygiene the prevention of disease.

Given that the education level of the mother is a significant effect or a positive trend in all of the models containing data from Ifotaka (tables 6-8), we investigated the various treatment strategies taken by mothers who had higher education and those who did not. There were 35 children who were ill in Ifotaka of which 8 mothers had attended secondary school and 27 had little or no education.

Table 12: The percentage of types of treatment for children who were ill in the past month for mothers who attended secondary school and those who did not.

	Medicines	Plants	No treatment
Mothers highly educated (n=8)	62.5	37.5	00.0
Mothers poorly educated (n=27)	70.4	18.5	11.1

It is interesting, from table 12, that mothers with a secondary education were more than twice as likely to treat an illness in their child with plants as women with primary or no education. A number of explanations for this difference can be found. These women may simply be more willing to admit to using plant remedies, not afraid of appearing unable to afford modern medicines or ignorant of modern remedies. Alternatively higher educated women may be more willing to trust their own knowledge over that of a professional health worker. Because medicinal plant use is associated with families where the woman is educated and lower disease risk is also found in these families, it is possible that these plants are effective against disease. A pharmacological analysis of these plants could provide interesting results.

Vaccinations

Childhood immunizations prevent illness and death from many diseases. The required immunizations for childhoods are polio, measles, DPT (active against diphtheria, tetanus and whooping cough) and BCG (active against tuberculosis and leprosy). Immunization cards of those who possessed them contained these vaccines but most women reported that five vaccines made up the full set. As vitamin A supplements are widely given in Madagascar (see footnote 3) it is possible that children with a 'full set' were also given vitamin A intravenously.

Vaccination cards were unavailable for the children living in Amboetse. The majority of these children had only one vaccination. In Amboetse and Morafeno, coughs made up a greater percentage of the illnesses than in Ifotaka, 48.1% compared to 28.6%. Immunization against pneumonia could result in a fall in coughing episodes in these areas.

The results of this study do indicate that vaccination status is an important predictor of absence of infections in children (table 10 and 11). This finding is in line with expectations and provides further impetus for governmental schemes to increase the distribution and administration of childhood vaccines to remote areas of Madagascar.

Reliability of the data

This study is cross sectional in nature. Although certain dietary components were found to predict the number of days ill in the children, the design does not show cause and effect. We can say only that certain dietary habits co-occur with a certain incidence of disease and not that a certain diet leads to less illness. Although none of the children included in the study were suffering at the time of study from a serious infection, it is possible that those who were reported as having a cough or a temperature ate differently from those who were free of illness at the time of study. The study could therefore be improved by including questions that asked if and how a child's diet had changed since being ill.

The dietary questionnaire only comprised the last 7 days. The study assumes that these last 7 days represent a usual intake. This may not be the case in all families. Many special events could have occurred in various families during the 7 days of the recall that affected dietary intake. Such events could be a funeral or marriage at which a zebu was slaughtered, or a trip to Fort Dauphin where a wide range of foods can be found. These events would increase the diversity score for that family and would decrease the size of a true effect such that a child that was chronically malnourished and prone to infection would have an inflated diversity score. Indicators of long-term malnutrition such as height-for-age score could have been taken to check the validity of the food diversity questionnaire. The food diversity questionnaire itself did not include any measure of quantity so the link between increased diversity and nutrient adequacy in this community must be presupposed based on links found in other studies (e.g. Hatloy *et al.*, 1998). A quantitative diet questionnaire would have improved this study by ensuring that diversity did in fact reflect a level of nutrient adequacy.

Another source of error was the evolution of the questionnaire during the study. The food list for the food diversity questionnaire was comprised as completely as possible before interview subjects were approached. After going through this entire list, each respondent was then asked to name any food items that had been consumed during the past 7 days that did not appear in the questionnaire and as these were added to the list. Subsequent interviews included asking about these new items. It is, therefore, a fault in the design that respondents later in the study were given a longer food list than those at the beginning. This is thought to have a limited impact, however, as many of the new food items were wild plants for infusions and there was a very low level of agreement between these plants by people who consumed them.

A large area of error is in the accuracy of recall in the respondents. This could be affected by the attention the respondent gave to the questions, whether they were distracted or eager to finish. One questionnaire was completely discounted as the respondent answered affirmatively to every food item n the list. Similar inaccuracy but less extreme may occur in responses from other respondents. Inaccuracy may also be incorporated due to a social desirability bias. This phenomenon was used previously to suggest the possibility that consumption of domestic animals is over represented. In a North American population, Herbert *et al.* (1995) found that social desirability of certain foods biased data from dietary surveys. They state that in their study, the bias was approximately twice as big for women as for men.

Accuracy could also be compromised by the fact that the questions were about the diet of the child but the respondent was the mother. The mother may not always be aware of what the child is eating, especially in the case of wild fruits as snack as has been discussed previously.

The diet survey was taken in one season only. The season of this study was the lean season, the end of the dry season and food was scarce. We would expect that a repeat of the dietary survey at the end of the rainy season would result in a longer list of food items and higher diversity score for all participants. Ogle *et al.* (2001) investigated wild vegetables in the diet of women living at the Mekong delta in Vietnam and found that wild plants comprise 63% of the total vegetable intake during the rainy season and 81% during the flood season indicating that seasonality plays a large role in this type of study. A study of wild fruits in Zimbabwe found that although fruits were most abundant at the end of the rainy season, most fruit collection activity was in the lean season, when fruits are not their most abundant (Campbell, 1987). It appears that in this community, wild fruits are eaten as supplementary foods when other foods are in short supply. It is therefore difficult to predict the size and direction seasonality has on diet diversity.

Seasonality also affects infection rate. An increase in child malnutrition has been documented during the lean season in Madagascar. A restriction in food intake along with the onset of rains can cause diseases such as diarrhoea and malaria to triple and in the capital of Madagascar, child mortality rates are lowest when the price of food is at the lowest (Dostie *et al.*, 2002).

This fact brings into question whether it is nutrient deficiencies or total energy deficiency that has the biggest impact on child health in the present study. A measure of calorie adequacy from a quantitative food questionnaire or anthropomorphic measures would be needed to understand this question.

General Conclusions

Food variety was not useful in determining susceptibility to infection in children in this community in general. The variety of foods within food groups are, however, possible predictors of infection rate. Diversity within the food group meat, and in particular wild meat, appears to decrease the susceptibility to infection in children in this community. Wild plants show a possible positive trend towards being beneficial to health and further study is needed into this component of the diet. Milk appears to negatively influence health, as does the diversity of cultivated foods; however it is unlikely that a large diversity of this last group has a direct negative impact on health but rather cultivated foods replace other essential dietary components.

This study does not provide a reliable rapid assessment of health based on a diet questionnaire. It is still possible that such a questionnaire could be developed. Such a questionnaire would probably focus on higher valued food such as meat and the consumption of wild foods. A better understanding of the consumption of wild plants at different times of the year would be needed to truly understand the value of this resource.

Socio-economic status has a large impact on illness form infection and these factors cannot be supplanted by a change of diet. Education levels of the mother and possession of childhood vaccinations by the child are clearly important determinants of health status in children. A comparison of Ifotaka with the other, less developed sites highlights the importance of basic technologies such as clean water, access to latrines and electricity.

The findings in this study emphasise the importance of forest resources in maintaining the health of people in this community. Efforts in forest management are essential to maintain the spiny forest and its fauna. The biggest threat to the natural habitat is urban sprawl and intervention at the government level would appear to be required to regulate this issue. Social and economic development programs in this area are also needed to reduce child morbidity and mortality rates. These should focus on access to education to all members of the communities and childhood vaccination programs reaching the more remote villages.

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Appendices

Appendix A: Completed Food List and Dietary Diversity Questionnaire.

Location________________________ Date ________________________

Malagasy	English	IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8
	Staples								
vary	Rice								
belahazo	Manioc								
tsako	maize								
bageda	sweet potato								
les pates	noodles (packet)								
	Complements								
ravina bageda	sweet potato leaves								
ravina belahazo	manioc leaves								
ravina tabouara	pumpkin leaves								
Chakamafana	*Spilanthes acmella*								
epinara	spinach								
tsiombike	Unidentified green leaf								
saramaso mena	red beans								
saramaso foty	white beans								
antake	*Dolichos lablab*								
vangemba	Cowpea								
katre	Peanuts								
vansoabary	round peas								
	Vegetables								
tongolo	spring onions								
tongolo be	large onions								
tomates	tomatoes								
tongolo lay	garlic								
tabouara	pumplin								
	potatoes								
fangitse	*Dolichos fangitsa*								
kabaro	pois de cap								
?	cucumber								
?	green mango								
atajagne	Unidentified root								
vizaha	Unidentified root								
	Fruits								
mangy	mango								
voasare makira	lemon								
kily	tamarind								
raketa	prickly pears								
akondro	bananas								
coeur de boeuf	custard apple								
	Domestic meat								
omby	beef								

osy	goat								
akoho	chicken								
vorotsilosa	turkey								
akanga	cguinea fowl								
anondry	sheep								
	Wild birds								
kibo	wild bird 1								
deho	wild bird 2								
foly	wild bird 3								
tsymitse	wild bird 4								
aliotse	wild bird 5								
takamboa	wild bird 6								
tsikoloto	wild bird 7								
rovakia	wild bird 8								
aliotse	wild bird 9								
heoke	wild bird 10								
tsivoke	wild bird 11								
	River Fish								
toho	river fish 1								
fiampoty	river fish 2								
saroy	*Ptychochromis sp.*								
tandregne	river fish 4								
lapia	river fish 5								
maze	river fish 6								
fiambazaha	river fish 7								
tsondro	river fish 8								
	dried fish								
	Animal Products								
atoly	egg								
ronono'omby	cows milk								
ronono'osy	goats milk								
rononohabobo	curdled milk								
	Other meats								
tsitsike	river shrimp								
amalo	eel								
tsora	Tenrec (small mammal)								
	Spices/Sugar/Other								
menake	vegetable oil								
poivre	pepper								
sira	salt								
carry	curry powder								
sakay	chili pepper								
sira mamy	sugar								
tantele	honey								
mofogasy	rice donuts								
mofomenake	maize donuts								
Baguette	french bread								
Biscuits	biscuits								

Bonbons	sugar sweets								
Fary	sugar cane								
	Drinks								
Ranonapango	Burnt rice in water								
Jus	powdered juice								
Sodas	coke, fanta etc								
Café	coffee								
Duthe	tea								
	Infusions of Wild Plants								
Veromanitse	lemon grass								
Nimo	wild plant 1								
Ambatre	wild plant 2								
Mandravasaotre	*Cinnamosma sp*								
Kidroy	wild plant 3								
	pumpkin flowers								
Bararata	reeds								
Saongaza	wild plant 4								
Voapike	*Allophylus sp.*								
Soazanahary	wild plant 5								
Lahindaivosake	wild plant 6								
Maimbo	wild plant 7								
Fantotsara	wild plant 8								
Tatavakibo	wild plant 9								
Olekoleke	wild plant 10								
Saretaho	wild plant 11								
Anagoloke	wild plant 12								

Q1: Did your child consume (insert food item from list) in the past 7 days?

Q2: Did your child consume any other foods or drinks not in the food list in the past 7 days?

Appendix B : Household and Disease Questionnaire

QUESTIONNAIRE de L'HABITAT et de la SANTE

HOUSEHOLD ID ________________ **LOCALITE** ________________

DATE ____________ **SEX**__________ **AGE**________________

SECTION 1 : TAUX D'INFECTION

101. Est-ce-que l'enfant a tombé malade pendant la mois précédante ? (p. ex. la diarrhée, la fièvre, le toux)

102. Combiens de jours la maladie a-t-elle durée ?

103. Pour chaque episode de (*maladie*) quelles mesures, en serie chronologique, avez vous prises pour combattre la maladie ?

MALADIE____________________

	MESURES PRISES POUR COMBATTRE LA MALADIE[1]			
DUREE	1	2	3	4
1.				
2.				
3.				

MALADIE____________________

	MESURES PRISES POUR COMBATTRE LA MALADIE[1]			
DUREE	1	2	3	4
1.				
2.				
3.				

104. Combiens de vaccins a eu ton enfant ?

104____________________

SECTION 2: SANTE ET SOINS

201. Ou se trouve la clinique le plus près du village ? **201**____________________

202. Est-ce-que cous avez visité cette clinique pour des soins pour quelqu'un de ta famille pendant l'année précédante ?

202____________________

203. Est-ce-que vous avez visité d'autre hopitals plus loins pendant l'année précedante? Lesquels ?

203____________________

204. Est-ce-que vous avez déjà acheté des médicaments pour quelqu'un dans ta famille pendant l'année précédante?

204____________________

205. Comment avez vous acheté ces médicaments ?
1=SUR ORDONANCE ; 2=AU MARCHE LIBRE

205____________________

206. Qui, parmis les membres de ta famille, connaît le plus sur les plantes médicinales ?

206____________________

207. Est-ce-que quelqu'un de ta famille a untilisé des plantes médicinales pendant l'année précédante?

207____________________

208. Est-ce-que quelqu'un de ta famille a visité un Ombiasy pendant l'année précédante?

208____________________

SECTION 3: EDUCATION

301 RESIDENT	202 SEX 1=M;2=F	303 ORIGIN ETHNIC[2]	304 RELIGION[3]	305 EDUCATION[4]	306 OCCUPATION
1					
2					
3					

SECTION 4: SANITATION

401. Comment est-ce que vous débarassez de l'excrement?

1=PIT LATRINE; 2=FORET; 3=UNE PELLE; 4=AUTRE

401 ____________________

402. D'ou viens l'eau utilitsée à la maison ?

1=LA RIVIERE; 2=POMPE D'EAU; 3=AUTRE

402____________________

403. Est-ce que il se trouve actuallement de savon à la maison?

1=OUI; 2=NON

403____________________

404. Est-ce-que il y a un objet electrique en état utile dans la maison?

404____________________

405. Combiens de chambres il y a t'il dans cette maison?

405____________________

SECTION 5: ALIMENTATION ET ECONOMIE

A: Animaux Domestiqués

	501 ANIMALE	**502** X MANGE PAR MOIS
1		
2		
3		

1=ZEBU; 2=CHEVRE; 3=MOUTON; 4=CANARD; 5=POULE; 6=PENTARD; 7=AUTRE

B: La Cultivation

	506 ESPECES CULTIVEES	**507** MOIS DE RECOLTE	**508** VENDU AU MARCHE

Appendix C: List of wild plants and their use by members of Ifotaka, Amboetse and Morafeno

Common name	Family	Scientific Name	To treat infectious disease	Consumed as food or tea	To cleanse stomach of infant 0-6mo	To help infants grow 0-6mo	To cleanse uterus after childbirth	To make people grow	Other	Total
Kily	FABACEAE	*Tamarindus indica*	0	43	0	0	0	0	0	43
Fangitse	CURCURBITACEAE	*Dolichos fangitsa*	0	10	0	0	0	0	0	10
Olekoleke			3	0	4	2	0	0	0	9
Tsiboroandrano			0	0	9	0	0	0	0	9
Boroa	LAMIACEAE	*Tetradenia nervosa, Tetradenia goudotii*	0	0	7	1	0	0	0	8
Fantotsara			0	3	1	1	1	0	2	8
Katrafay	RUTACEAE	*Cedrelopsis sp.*	0	0	5	1	0	0	2	8
Pisopiso	LYTHRACEAE	*Koehneria madagascariensis*	0	0	6	2	0	0	0	8
Sangatry	CONVOLVULACEAE	*Argyreia onliahiensis*	0	0	8	0	0	0	0	8
Vahifoty			1	0	2	4	0	0	1	8
Reringitse			0	0	7	0	0	0	0	7
Mandravasaotre	CANELLACEAE	*Cinnamosma sp.*	0	3	1	1	0	0	1	6
Voapike	SAPINDACEAE	*Allophylus sp.*	3	1	2	0	0	0	0	6
Pumpkin flowers			0	0	5	0	0	0	0	5
Tsiombike			0	5	0	0	0	0	0	5
Hazomena	EUPHORBIACEAE	*Securinega seyrigii*	0	0	0	0	1	1	2	4
Lairike			0	0	4	0	0	0	0	4
Relefo			0	0	4	0	0	0	0	4
Vahombe	LILIACEAE	*Aloe vahombe*	0	0	1	0	2	0	1	4
Citronelle	POACEAE	*Cymbopogon citratus*	0	3	0	0	0	0	0	3
Dagoa			0	0	3	0	0	0	0	3
Obognebogne			1	0	0	2	0	0	0	3
Varo			0	0	0	0	1	0	2	3
Lambroso			0	0	2	0	0	0	0	2

Common name	Family	Scientific Name	To treat infectious disease	Consumed as food or tea	To cleanse stomach of infant 0-6mo	To help infants grow 0-6mo	To cleanse uterus after childbirth	To make people grow	Other	Total
Mafaibelo	LOGANIACEAE	*Strychmos decussata*	1	0	0	0	0	0	1	2
Sahondra			0	0	1	1	0	0	0	2
Soazanahary			0	1	1	0	0	0	0	2
Taritarike			0	0	0	0	1	0	1	2
Vahimasigne			0	0	0	1	0	1	0	2
Voamena			0	0	1	1	0	0	0	2
Aloy			1	0	0	0	0	0	0	1
Ambatre			1	0	0	0	0	0	0	1
Andranahake			0	0	0	0	0	0	1	1
Angalora			0	0	0	0	0	0	1	1
Barata			0	0	0	0	0	1	0	1
Copycopydambo			0	0	0	0	0	1	0	1
Famanty			0	0	1	0	0	0	0	1
Famoty			0	0	1	0	0	0	0	1
Hazolava			0	0	0	0	0	0	1	1
Hiligne			0	0	0	0	1	0	0	1
Kifafa			0	0	1	0	0	0	0	1
Kidroy			0	1	0	0	0	0	0	1
Lahindahivosake			1	0	0	0	0	0	0	1
Mangerevoreke	MELIACEAE	*Turraea sp.*	1	0	0	0	0	0	0	1
Nimo			0	1	0	0	0	0	0	1
Papaya			0	0	0	0	1	0	0	1
Sarifitovy			1	0	0	0	0	0	0	1
Sofasofa			0	0	0	0	1	0	0	1

Common name	Family	Scientific Name	To treat infectious disease	Consumed as food or tea	To cleanse stomach of infant 0-6mo	To help infants grow 0-6mo	To cleanse uterus after childbirth	To make people grow	Other	Total
Tatavakibo			1	0	0	0	0	0	0	1
Tihinta			0	0	0	1	0	0	0	1
Trotroiake			1	0	0	0	0	0	0	1
Tsikimenamena			1	0	0	0	0	0	0	1
Tsimena			1	0	0	0	0	0	0	1
Vahimasy			0	0	0	0	0	0	1	1
Vahiranga			0	0	0	0	0	0	1	1
Votofosa			0	0	0	0	1	0	0	1
Zijime			1	0	0	0	0	0	0	1