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Uppsala 2012

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Credits: 15 hec
Level: G2E
Course title: Självständigt arbete I livsmedelsvetenskap
Course code: EX0426
Programme/education: Agronom - livsmedel

Place of publication: Uppsala
Year of publication: 2012
Picture Cover:
Title of series: Publikation/Sveriges lantbruksuniversitet, Institutionen för livsmedelsvetenskap
no: 339
ISSN:
ISBN:
Online publication: http://stud.epsilon.slu.se

Key Words: anemia, dietary intake, Fe, iron, metal contamination, Red River delta, Vietnam, zinc, Zn

Abstract

In many developing countries, among them Vietnam, contamination of agricultural land is a major issue that has public health implications. A fast growing population, rapid urbanization and industrialization have led to air and water emissions of potentially toxic elements (PTEs), such as cadmium (Cd). Earlier studies have shown that individuals with low iron (Fe) and zinc (Zn) status absorb larger quantities of Cd than those of adequate nutritional status.

The purpose of this study was to investigate and compare the Fe and Zn intake from the foods consumed by women (15-45 years) in selected households in two agricultural villages in the Red River delta in Vietnam. In one of the villages the residents were involved in metal (mainly Fe) recycling activity, whereas in the other village the residents had agricultural production as main source of income. Interviews, followed by food intake calculations, were performed. In total, 59 women were interviewed about their food intake as well as their knowledge about anemia, and the prevalence of this disease. The Zn and Fe intake values were compared to the nutrition recommendations for these elements. In the iron recycling village, the Zn intake was 12.7 mg/day/person and the Fe intake was 11.8 mg/day/person, based on the food intake a typical day. In the reference village, the Zn intake was 15.4 mg/day/person and the Fe intake was 13.2 mg/day/person. Based on a Food Frequency Questionnaire (FFQ), in the iron recycling village the Zn intake was 11.8 mg/day/person and the Fe intake was 11.1 mg/day/person, while in the reference village, the Zn intake was 12.1 mg/day/person and the Fe intake was 13.0 mg/day/person. The reasons for these differences between the villages are difficult to establish, but may be due to different eating habits regarding amounts and choice of food.

When comparing the Zn intake with the nutrition recommendations from the Vietnamese National Institute of Nutrition (NIN), as well as World Health Organization (WHO) and Food and Agriculture Organization (FAO), the Zn intake is higher than the recommendations. However, the Fe intake in both villages did not reach the Fe recommendations, regardless if comparing with the recommendations from NIN or WHO. For this reason, the women in this study may be more prone to absorb Cd.

In the iron recycling village, 93 % had knowledge about anemia and 14 % was suffering from it. In the reference village, the proportions are 100 % and 32 % respectively.

The Zn content is high in for instance beef, clams and cheese, and the Zn need for the women in this study is fulfilled. There are different strategies to improve the Fe status of Vietnamese women. Apart from increasing the intake, through certain foods rich in Fe, the status can be improved by eating foods that enhance absorption and avoid or lower the intake of foods that inhibit absorption. Information from the National Institute of Nutrition and medical stations is another important factor when improving the health status.

Keywords: anemia, dietary intake, Fe, iron, metal contamination, Red River delta, Vietnam, zinc, Zn

Sammanfattning

I Vietnam och många andra utvecklingsländer är föroreningar av jordbruksmark ett stort problem, vilket kan medföra hälsofaror. En snabbt växande population, snabb urbanisering och industrialisering har lett till luft- och vattenföroreningar av kadmium (Cd) och andra potentiellt giftiga ämnen (PTE:s). Tidigare studier har visat att individer med en låg järn- och zinkstatus absorberar större mängder Cd än de som har en bra näringsstatus av dessa ämnen.

Syftet med denna studie var att undersöka och jämföra det dietära intaget av järn (Fe) och zink (Zn) hos kvinnor (15-45 år) i två byar, belägna i Röda flodens delta i Vietnam. I en av byarna arbetade invånarna med metallåtervinning (i huvudsak järn), medan jordbruk var den främsta inkomstkällan i den andra byn, referensbyn. Hemintervjuer användes för insamling av data. Totalt intervjuades 59 kvinnor om sitt matintag, såväl som om sin kunskap om anemi och ifall de själva var drabbade av denna sjukdom. Intaget av Fe och Zn jämfördes med både nationella och internationella näringsrekommendationer. I järnåtervinningsbyn var Zn- och Fe-intaget 12,7 mg/dag/pers respektive 11,8 mg/dag/pers, baserat på matintaget en normal dag. I referensbyn var Zn-intaget 15,4 mg/dag/pers och Fe-intaget 13,2 mg/dag/pers. Utifrån Food Frequency-frågeformuläret (FFQ) var Zn-intaget 11,8 mg/dag/pers och Fe-intaget 11,1 mg/dag/pers i järnåtervinningsbyn, medan Zn-intaget var 12,1 mg/dag/pers och Fe-intaget 13,0 mg/dag/pers i referensbyn. Anledningen till denna skillnad mellan byarna är oklar, men olika matvanor när det gäller mängder och typ av mat, kan var en förklaring.

Vid jämförelsen av Zn-intaget i byarna med näringsrekommendationerna från National Institute of Nutrition (NIN) i Vietnam, såväl som rekommendationerna från World Health Organization (WHO) och Food and Agriculture Organization (FAO), visade det sig att Zn-intaget var högre än de rekommenderade värdena. Däremot nådde inte Fe-intaget i någon by upp till rekommendationerna för Fe, oavsett om de jämfördes med NIN:s eller WHO:s rekommendationer. Därmed anses kvinnorna i denna studien riskera att vara mer benägna att absorbera Cd.

I järnåtervinningsbyn uppgav 93 % av de intervjuade kvinnorna att de hade kunskap om anemi och att 14 % led av sjukdomen. I referensbyn var motsvarande siffror 100 % respektive 32 %.

Det finns olika strategier när det gäller att förbättra Fe-statusen för vietnamesiska kvinnor. Förutom att öka intaget genom att äta mat med högre mängd Fe, kan statusen ökas genom att välja mat som ökar absorptionen av Fe. Vidare kan man undvika eller minska intaget av mat som försämrar absorptionen. Informationsspridning från NIN och vårdcentraler är en annan viktig faktor när det gäller att förbättra hälsostatusen hos kvinnorna i dessa byar.

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1 Introduction

Agriculture constitutes an important part of the Vietnamese economy. In 2004 the agricultural sector represented 22 % of the Gross Domestic Product (GDP) (Swedish National Encyclopedia, 2009). More than 75 % of the population of Vietnam lives in rural areas, and most of them in the river deltas. Nearly 8 out of 10 people of low socio-economic status rely on agriculture for their living. Generally, the poorest people live in the rural areas and they often cultivate land that is degraded, and the possibilities to get occupations other than farming are limited (IFAD, 2010).

Micronutrient deficiency is a severe worldwide problem affecting primarily women and children. Every year over 30 million people die due to malnutrition around the world, mostly in the developing countries. Many poor families have an insufficient intake of essential micronutrients, e.g. iron (Fe) and zinc (Zn), in the diet, and this can cause malnutrition (Alloway, 2008).

Contamination of agricultural land is a major issue affecting public health in many developing countries, among them Vietnam, where fast growing populations, rapid urbanization and industrialization has led to air and water emissions of potentially toxic elements (PTEs). Furthermore, the wastewater treatment facilities are often rudimentary or non-existent. A concern coupled with this is when this wastewater is used as a source of irrigation, since PTEs have the capacity to accumulate to critical levels in the soil and can also be taken up by the crops. However, the PTEs are not necessarily a disadvantage for the plants, as some of them, such as copper (Cu), nickel (Ni) and Zn, are also essential micronutrients. Though, elements like lead (Pb) and cadmium (Cd) are non-essential and unwanted in crops consumed by humans.

PTEs are toxic even at low concentrations and can therefore be a health risk for individuals consuming crops contaminated with these elements (Marcussen *et al.*, 2008, Hagberg 2009). A low Fe intake can enhance the Cd absorption, which has been shown by animal experiments (WHO, 1996).

This study is linked to an ongoing Sida-SAREC funded research project called ”Assessment of environmental and public health risks due to metal contamination in villages in Vietnam” (SWE-2008-265). The Sida/SAREC project includes studies in several metal-recycling villages in the Bac Ninh Province located in the Red River Delta in the northern Vietnam.

In the recycling villages small scale industry, such metal-recycling, is a part of the household activities (Öborn *et al.*, 2008) (Fig. 1). The metal-recycling leads to contamination of the air, water and soil environment, and potentially toxic elements such as Cd and Pb from the recycling activities can be taken up by the crop plants. Since these crops are consumed by inhabitants in the villages, this metal-recycling constitutes a potential health risk (Hagberg, 2009).

Figure 1. Iron recycling factories in Tu Son.

In the Sida/SAREC project paired soil-rice samples have been taken in the study villages and also locally grown vegetables have been analyzed. In addition, drinking water wells have been sampled. In order to estimate the potential metal exposure through dietary intake and other sources (occupational exposure, smoking etc) a household survey was performed in 2007 using questionnaire and semi-structured interviews. The questionnaire covered occupational exposures, smoking habit, households food production including fertilizer and wastewater use, food and drink consumption, number of members of the household, as well as anthropometric data including age, gender, height, weight and other variables (Sida-

SAREC project SWE-2008-265). The information obtained was put together in an Access database.

In this thesis we investigated the dietary intake of Fe and Zn by some Vietnamese populations with a focus on women. We also discussed the disease Fe-deficiency anemia and its linkage to the diet. This included the effects of low Fe and Zn intake, especially concerning women. The issue of environmental contamination, in particular Cd, and the health effects that follow from that, are other questions that will be discussed in this study.

2 Aims and objectives

The purpose of this thesis was to investigate and compare the Fe and Zn intake in the food consumed by the women (15 - 45 years old) in selected households in two villages in the Red River delta in northern Vietnam. The nutritional dietary intake of Fe and Zn was compared to the national and international nutrition recommendations of these elements. On the basis of the results, we discuss the potential health risk for women from environmental contamination, in particular Cd exposure. Another purpose was to investigate the prevalence of and the knowledge about anemia in these villages.

The hypothesis to be tested in this study was that the women in the two villages do not achieve the Fe and Zn requirements through their dietary intake. This can depend on their economic situation, but also insufficient information about the importance of having a good nutritional balance. Another hypothesis was that there is a difference in Fe and Zn intake between the two study villages. Even since the average consumption habits of the women probably are similar in both villages, the off-farm income in the iron recycling village can contribute to a better economy and more money spent on more expensive foods with higher content of Fe and Zn.

3 Background

3.1 Zn, Fe and its deficiency diseases

3.1.1 Correlation between Fe and Zn status and Cd absorption

In Vietnam the diet is considered as being rice-based. It is well established that, while rice is a valuable source of energy and protein, diets in rice-based cultures often are deficient in several important nutrients, particularly Fe and Zn (Alloway, 2008; Chaney, 2010).

The consequences of food and micronutrient deficiencies of malnutrition are compounded by contamination of the food chain with PTEs such as Cd and arsenic (As). Studies have shown that individuals with low Fe and Zn status adsorb larger quantities of PTEs than those of adequate nutritional status (Tsuchiya, 1976; McKenna *et al*., 1992; Kippler *et al*., 2007).

The absorption of Cd in the human body varies a lot between people, individuals with Fe deficiency and low Fe stores can have up to 20-30 % higher absorption (Apinan, 2009).

Zn and Fe are antagonists to Cd. In animal experiments on rats it has been shown that when giving a diet high in Zn, Fe and/or Ca, the rate of absorption of Cd in these animals was reduced (Reeves *et al*., 2004).

Since women have a tendency to be afflicted with anemia, they also are a more vulnerable group for elevated Cd absorption (Öborn *et al*., 2008). Similarly, a study by Apinan (2009), shows an increased rate of Cd absorption in women with Fe deficiency.

3.1.2 Anemia

Globally, anemia is a widespread health problem, 24.8 % of the world population is affected by anemia, which corresponds to 1.62 billion people. The prevalence is higher amongst pregnant women and young children (WHO, 2008).

Anemia means that the blood has a reduced capacity to transport oxygen, and this condition can be caused by insufficient intake of Fe through the diet (Sand, 2007). Even if Fe deficiency probably is the most common cause of anemia, anemia can also be caused by other conditions (WHO, 2007). Around 50 % of anemia cases worldwide are caused by Fe deficiency. Fe-deficiency anemia is primarily due to low Fe intake, low Fe absorption from diets containing large quantities of phytate or phenolic compounds, and due to pregnancy and growth when the requirements of Fe are higher than normal (WHO, 2008). “Anemia” in this thesis refers to Fe-deficiency anemia.

3.1.3 Fe and Zn in the diet

Iron has different functions in the human body. It is an important component of hemoglobin and multiple of enzymes. Foods that have high contents of Fe are meat, intestines and food made from animal blood, leafy green vegetables and leguminous plants. In general, a person with a normal Fe status absorbs around 15 % of the Fe from a mixed animalic diet. There are two different absorption possibilities for Fe, one for heme Fe and one for non-heme Fe. These two are independent of each other (Abrahamsson *et al*., 2006). Examples of non-heme sources of iron include fruits, vegetables and fortified bread and grain products. Heme iron sources are mainly meat and poultry (Institute of Medicine of the National Academies, 2009). About 25 % of the heme iron is absorbed from the diet, and the absorption is not notably affected by the composition of the diet. However, the non-heme iron absorption can be affected by simultaneous intake of certain foods. Meat and foods rich in vitamin C can increase non-heme iron absorption, while tea, coffee and cacao contains polyphenols, substances that restrain the absorption (Abrahamsson *et al*., 2006; Benito *et al*., 1998). Vegetarians are recommended an Fe intake twice as high as for non-vegetarians, since the non-heme iron absorption is lower for people eating vegetarian diets (Institute of Medicine of the National Academies, 2009).

Zinc is a component of proteins and numerous enzymes and is also important when it comes to the regulation of gene expression (Institute of Medicine of the National Academies, 2009). Foods rich in Zn include beef, clams, cheese and soya beans. Seeds, nuts and multi grain products also have high Zn content, but these also contain much phytic acid that can restrain the Zn absorption. Animalic protein can on the other hand increase the utilization of Zn (Abrahamsson *et al*., 2006). Like Fe, the absorption of Zn is lower for people eating a vegetarian diet than those consuming a non-vegetarian diet, and a two times higher intake is therefore recommended for vegetarians (Institute of Medicine of the National Academies, 2009).

3.1.4 Nutrition recommendations

The nutrition recommendations varies depending on administrative authority and country. In addition to the Fe and Zn recommendations from National Institute of Nutrition (Tables 1, 2), the Zn requirements from WHO and the Fe recommendations from WHO/FAO are presented.

Table 1. Average individual female recommendations for Zn intake (mg/day)

Age range (years)	Recommendation (mg/day), average bioavailability of 30 %			Source
10-18		7.8		NIN[1]
19-50		4.9		NIN[1]
	Recommendation (mg/day), different levels of bioavailibility:			
	High availability	Moderate availability	Low availability	
15-18	2.7	4.5	9.1	WHO[2]
18-60+	1.7	2.9	5.8	WHO[2]

[1] (Nguyen Cong Khan *et al*., National Institute of Nutrition, 2007). Average individual female requirements, with an average bioavailability of 30 % taken into account.
[2] (WHO, 1996). Average individual female normative requirements, from diets differing in Zn bioavailability. The calculations are based on a woman with a body weight of 48.5 kg.

Iron absorption is highly variable depending on the diet. Therefore the Fe requirements have to be adjusted to the bioavailability in the diet. In the report "Human Vitamin and Mineral Requirements" by WHO/FAO (2002), four different bioavailability levels were used: 5, 10, 12 and 15 %. For developing countries, WHO/FAO consider 5 or 10 % as realistic levels (Table 2).

Table 2. Average individual female recommendations for Fe intake (mg/day) from diets differing in bioavailability

Age (years)	Mean body weight	Recommended Fe intake (mg/day) % Dietary Fe bioavailability 5	10	Source
13-18			41.3	NIN[1]
19-50			39.2	NIN[1]
11-14*	46.1	65.4	32.7	WHO/FAO[2]
15-17	56.4	62	31	WHO/FAO[2]
18+	62	58.8	29.4	WHO/FAO[2]

* Menstruating

[1] (Nguyen Cong Khan *et al*., National Institute of Nutrition, 2007). Average individual female requirements. The bioavailibility is considered to be 10 % for females in Vietnam (e-mail correspondence, Ms Ha, NIN, 2010).

[2] (WHO/FAO, 2002). Average individual female recommended intake.

3.1.5 Dietary intake of Fe in Vietnam

In a survey in 2000 by National Institute of Nutrition (NIN) in Vietnam (n = 7 658 households), the Fe intake was 11.16 ± 4.26 mg/person/day. However, this survey included both men and women (National Institute of Nutrition, 2000). In Red River Delta Region, the corresponding number was 11.68 ± 3.64.

3.2 Cd and related health effects

Cadmium is a PTE that occurs in the environment from both anthropogenic and natural sources.

The toxicity of Cd is high and it affects both the environment as well as human health. The effects can be acute or chronic. The main target organ in the body where Cd accumulates is the kidneys (WHO, 2003), where it is deposited for many years. The half-life of Cd in the kidneys is 30 years (Apinan, 2009). One critical health effect is renal tubular damage. Hypercalciuria and formation of kidney stones is other health effects of Cd exposure (WHO, 2003).

Since Cd is chemical element it will stay in circulation, once it is released. Thus, the amount of Cd in the environment increases gradually since new releases constantly take place. Cadmium compounds have fairly high chemical solubility, which means that the mobility of this metal, in for example soil, is higher compared to other PTEs that are less soluble, e.g. Pb. Therefore, Cd is more bioavailable and has a higher tendency to bioaccumulate (WHO, 2003).

One of the most important issues to take in consideration, related to Cd, is that the human intake of this heavy metal is increasing, since the Cd content in agricultural top soil is increasing. This is because of the constant atmospheric deposition of Cd and due to Cd contamination of many P-fertilizers (WHO, 2003).

4 Methods

4.1 Description of study sites

The iron recycling village Chau Khe is located in the northern part of Tu Son district, Bac Ninh Province (Fig. 2). The village has a total population of 13,930 people divided in 2,930 households (Minh, 2007). The land area is about 500 ha, where agricultural land makes up 56 % of the total area and 5 % of the land is used for industrial purpose.

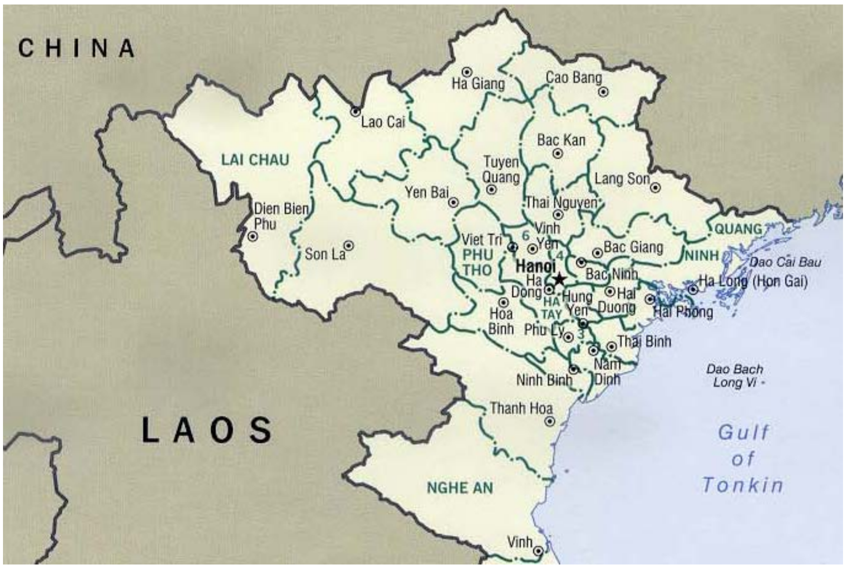

Figure 2. Map of northern Vietnam.

About 60 % of the households in Chau Khe are involved in the iron recycling. The recycling includes both small-scale production within the residential quarter, where primitive technology is used, and industry-scale production with larger-scale equipment and machines (Ifediora, 2009) (Figs 3, 4). The recycled material consists of waste and scrap iron. The scrap iron is collected from different regions in Vietnam and some of it is imported from Japan and is formed into many different kinds of steel products, like wires, bars and pipes. One thousand tons steel and iron products are produced in the village every day and 6000-7000 workers are involved in this industry (Minh, 2007).

Since wastewater from the iron recycling is used to irrigate the rice fields, heavy metals are transmitted to the soil and the crops. Rice and vegetables are the main crops grown in the village (Ifediora, 2009).

It is shown that there are considerably higher amounts of for example Cd in the soil in the metal recycling village as compared to reference areas, suggesting that the contamination of heavy metals is higher because of the metal recycling activities (Öborn *et al*., 2008).

Figure 3. A man transporting steel wires in the iron recycling village.

Figure 4. An iron recycling industry.

4.1.1 Reference village

The reference village Co Loa is located in the southern part of Dong Anh district, Hanoi province (Fig. 2). In the reference village, there is no metal recycling activity. There are 4,530 households in the village, of which 80 % of these rely on agriculture as their primary source of income. The total population is 16,800 people. The land area is just over 800 ha and 60 % of this is agricultural. Rice is the dominant crop grown in the village, but also vegetables and other crops are grown (Co Loa Commune People's Committee, 2009).

4.2 Questionnaires and interviews

Field studies in the form of interviews were undertaken during the spring in 2010, to investigate the Fe and Zn intake of the women in the villages. The interviews were performed in both villages.

To select the households for the interviews, the Access database linked to the ongoing Sida/SAREC research project was used. The households including women between 15 and 45 years old were selected. The reason for choosing women in this age interval was because it corresponds to women of childbearing age. In this age women are more vulnerable for Fe deficiency and consequently also for elevated Cd absorption. The interviews were retrospective and asked about a typical day - the day just passed if this was typical. All meals and foods were asked to be reported. Water and other beverages were not asked for.

After agreement with local authorities and villagers, home visits were performed in order to carry out the interviews. The interviews were performed in Vietnamese. The aim was to interview 20 households in each village. However, this was not viable, since some household members were not at home at the time of the interview. This resulted in 18 interviews in the reference village, and 21 interviews in the iron recycling village. As some households had more than one woman between 15 and 45 years old, the total number of interviewed women was 31 in the reference village and 28 in the iron recycling village. The two research teams consisted of three persons each: one Vietnamese supervisor from Soil and Fertilizer Research Institute (SFRI), one Vietnamese student from Hanoi University of Science (HUS) and one Swedish student from Swedish University of Agricultural Sciences (SLU). These two teams were synchronized in order to achieve an equal interview technique and minimize bias. The teams were working together both when test interviews were carried out and at the first real interview in the first village. The two teams of interviewers went to the same village and split the interviews between them.

A household questionnaire, comprised of both open and closed questions (Appendix 1), was used as a tool to collect the information during the interviews. This questionnaire was developed in English and after improvements translated into Vietnamese. The content of the questionnaire was discussed with relevant advisors, such as National Institute of Nutrition (NIN) in Vietnam and both Swedish and Vietnamese supervisors. Some of the advisors have been working with the questionnaire used in the household survey in 2007 and were therefore informed by their experiences with this earlier survey. The questionnaire was amended before the final version was produced. Before the real interviews took place, test interviews were carried out and then the questions were improved over again before translation.

In this new study, the interviews and questionnaire had more focus on the diet of the female inhabitants and especially the food sources rich in Fe and Zn. In the present questionnaire, a more detailed food-frequency questionnaire (FFQ) was included, to find out how often the women consume specific kind of foods. Consumption of foods, amount and frequency, were captured by asking the women how many days a week they ate that amount of that food, how many weeks per month, and then how many months of the year.

When asking about the amounts, both for the typical day and the FFQ, a photo album with pictures of plates with food with specified amounts (provided by NIN) was used to obtain as correct values as possible. Questions about food purchase were also asked. In the survey in 2007 a question about the food intake of the inhabitants in a typical day was used. This question was also used in the present survey. The types of food that were included in FFQ, were chosen in regard to both food commonly consumed by the Vietnamese population and food rich in Fe and Zn. Concerning the meat, it was split up in the subcategories chicken/duck, beef/buffalo, pork, dog and fish, since the nutrition values for these foods varied a lot. Similarly, the intestines was subdivided into categories, such as liver and kidney. Egg and tofu were also included in the FFQ table, as well as banana, pineapple, guava and other fruits. Also vegetables, such as water spinach and sweet potato leaves, were asked for. Questions about anemia and diet habit changes compared to five years back, as well as questions about the use of dietary supplements, were also added to the questionnaire. The translation of the answers from Vietnamese to English was made in collaboration with the Vietnamese students.

Interviews with the medical stations in the iron recycling village and the reference village were performed, to get better knowledge about their work to prevent anemia, but also to obtain local statistics about anemia prevalence.

An interview with NIN was also performed, to receive background information about national anemia prevalence, Fe and Zn deficiency statistics in Vietnam and recommendations for the upcoming interviews.

4.3 Calculations

4.3.1 Mean values for Zn and Fe intake

The dietary Fe and Zn intake was calculated based on the questionnaire data and the Fe and Zn concentrations in all foods given in published food databases, expect for rice and water spinach. Mainly, the National Nutrient Database of United States Department of Agriculture (USDA), was used. In exceptional cases, when a specific food item could not be found in the USDA database, the Swedish Food Database of the National Food Administration in Sweden was used. The local values for Fe and Zn in rice and water spinach were taken from the Sida/SAREC project database. For water spinach the same Fe and Zn concentrations were used for both villages, whereas site specific data were used for rice metal concentrations. The Fe and Zn values for rice in the Sida/SAREC project database were given in uncooked condition and therefore a conversion table (Appendix 2, Table A4) was used to get the values for cooked rice.

All values from both a typical day and the FFQ were entered into Microsoft Excel for calculating the total intake of Fe and Zn for each individual. For the FFQ, the frequency, the amount and the share were inserted, and also in this case, the excel-program was used to calculate the amount of Fe and Zn for each individual. Since the recommendations for Zn vary with body weight, the mean value of the body weight for women in the two villages (48.5 kg) was used when calculating the normative requirements.

In addition to the earlier mentioned food asked for in the FFQ, the households in the iron recycling village were asked about the eaten amount of rice in the FFQ. From this, a mean value for the rice intake was calculated and used for all women in both villages.

4.3.2 Food sources contributing to the Zn and Fe intake

In a typical day, many types of foods were reported. To visualize which of those contributing to the biggest Zn and Fe intake, pie charts were made. Based on different food pyramids (Figure 5) and discussions with supervisors, the reported foods were divided into following eight categories:

- *Rice, noodles, bread and cereals:* rice, noodles, vermicelli, rice pudding, instant noodles, sticky rice, corn, bread, sticky rice cake
- *Leafy green vegetables:* amaranth leaves (rau dền), cabbage, water celery, cress, mustard greens, pumpkin leaves, rape bird, sauropus leaves (*Sauropus androgynus;* rau ngót), chayote leaves (*Sechium edule*; su su or trái su) , sweet potato leaves, vine spinach, water spinach
- *Other vegetables, and tubers:* calabash, cucumber, eggplant, gourd, radish white, tomato, potato
- *Fruits:* bell fruit, banana, fig, mango, melon, pineapple, plum, water melon
- *Meat, poultry, fish and egg:* beef, pork, dog, chicken, goose, intestine from chicken, snail, crab, fish, shrimps, egg
- *Dairy products:* milk, yoghurt
- *Tofu:* tofu
- *Pulses:* kidney beans, cow peas, peanuts, mungo bean sprout, mungo bean

Figure 5. The Vietnamese food pyramid from National Institute of Nutrition. Noodles, bread and corn can be seen in the base of the pyrimide, vegetables at the next step and fruit on the third step. Above the fruit are protein rich foods as fish, egg and meat placed and above this level oil and fat can be seen (Photo from Public Notice Board at National Institute of Nutrition, 2010).

The reason for separating leafy green vegetables from other vegetables is that these leafy green vegetables constitute a big share of the eaten amount of food.

Moreover, leafy green vegetables, such as amaranth leaves and pumpkin leaves also have a much higher content of Fe than cucumber, radish, tomato and the other foods sorted under the category “other vegetables and tubers”.

Tofu was allocated to its own category. Like egg and meat, it has a high content of Fe, but there were some women that distinguished when it came to eaten amount of tofu, and we thought it was important to understand how much tofu alone contributed to the total Fe intake.

For each woman, the contribution of each food category to the individual total Zn and Fe intake, respectively, was calculated. Mean values for each food category were then calculated, to obtain a overview for both villages. Mean values for the five women with the highest and the five with the lowest values in each village were also calculated, to explore possible differences in which food categories they got their main Zn and Fe intake.

5 Results

5.1 Age, weight and BMI

The distribution of age, weight and BMI, as well as the classification into age categories, was very similar when comparing the two villages. Of the interviewed women, most females belong to the age category 15-25 years old (Tables 5, 6).

Table 3. Age, weight and BMI for the interviewed women

	Iron recycling village (n=28)		Reference village (n=31)	
	Mean value	Median	Mean value	Median
Age	29,3	30,0	27,5	26,0
Weight	48,0	48,0	49,0	48,0
BMI	20,2	19,4	19,7	19,3

Table 4. Number of interviewed women in each age category

Age category (year)	Iron recycling village (n=28)	Reference village (n=31)
15-25	14	12
26-35	9	9
36-45	8	7

5.2 Fe and Zn intake

5.2.1 Zn and Fe intake per day and person

The average dietary intake of Fe was similar in the reference village and in the iron recycling village, according to both a typical day and the FFQ. The average dietary intake of Zn based on the FFQ was similar in the villages. (Table 5, Figs 6-9). Only in one case - the Zn intake based on a typical day - the values was significant different (p-value 0.005), with higher intake in the reference village.

Table 5. Fe and Zn intake per day and person

	Based on typical day from questionnaire		Based on FFQ from questionnaire	
	Zn intake (mg/day and person)	Fe intake (mg/day and person)	Zn intake (mg/day and person)	Fe intake (mg/day and person)
Iron recycling village	12.7 ± 3.0	11.8 ± 4.4	11.8 ± 2.8	11.1 ± 4.7
Reference village	15.4 ± 4.1	13.2 ± 4.3	12.1 ± 2.8	13.0 ± 5.2

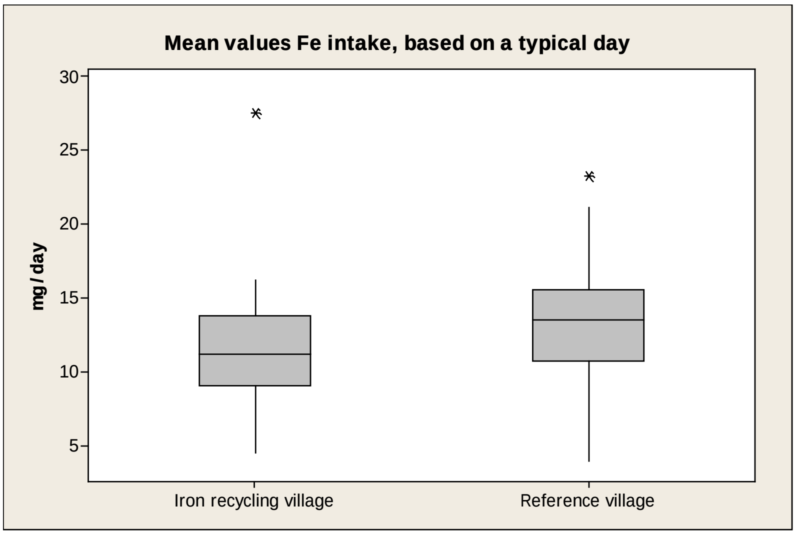

Figure 6. Mean values for Fe intake (mg/day and person) in the iron recycling village and the reference village respectively, based on a typical day.

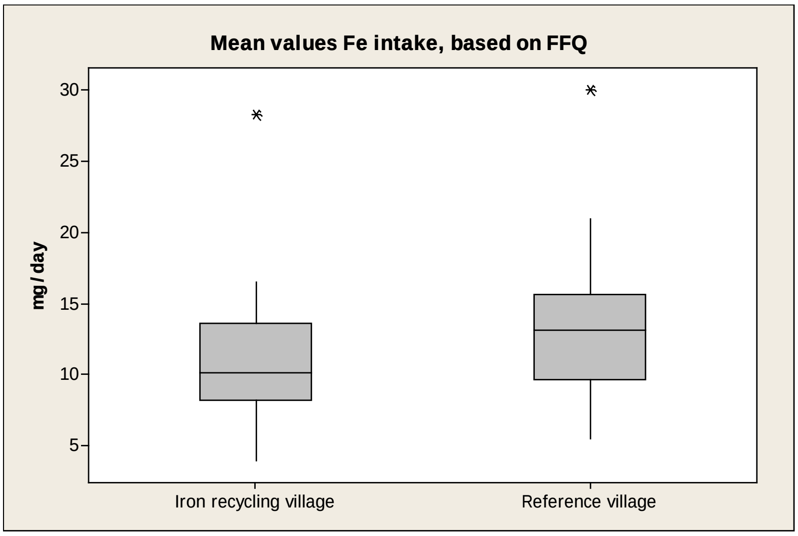

Figure 7. Mean values for Fe intake (mg/day and person) in the iron recycling village and the reference village respectively, based on FFQ.

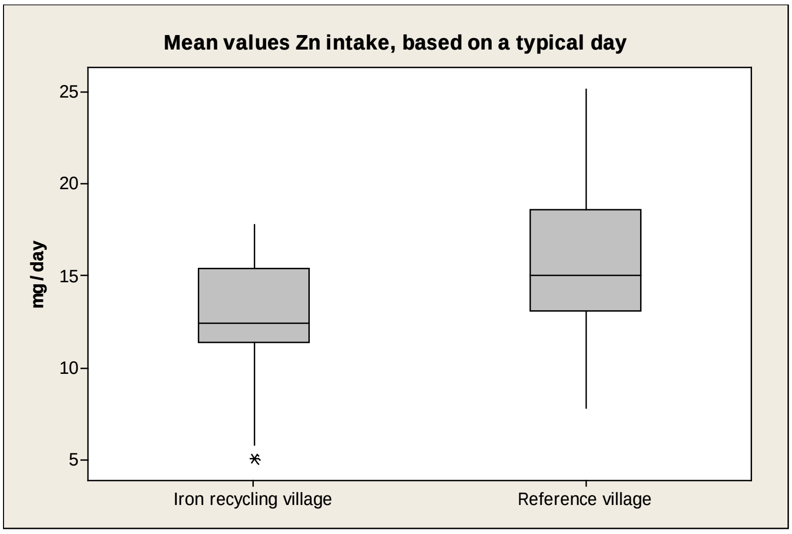

Figure 8. Mean values for Zn intake (mg/day and person) in the iron recycling village and the reference village respectively, based on a typical day.

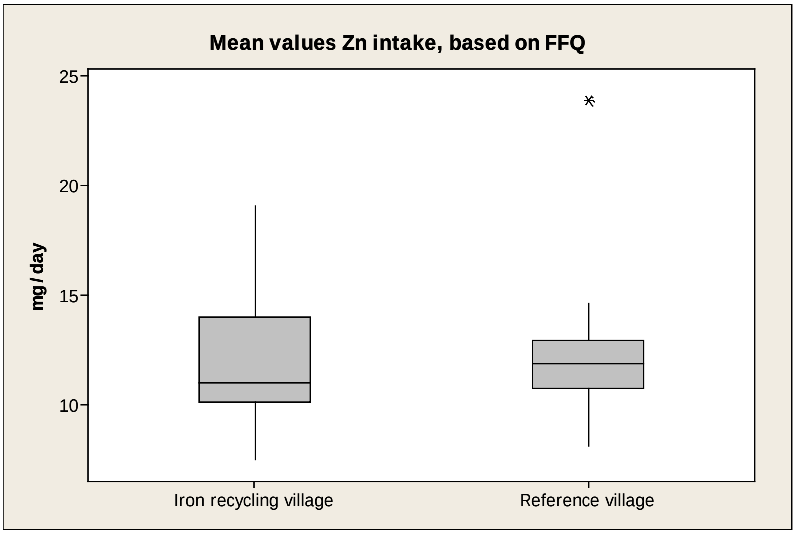

Figure 9. Mean values for Zn intake (mg/day and person) in the iron recycling village and the reference village respectively, based on FFQ.

5.2.2 Food sources contributing to the Fe and Zn intake

The eight food groups contributed to different extent to the Zn and Fe intake, when comparing the food intake a typical day in the iron recycling village and the reference village. Rice, noodles, bread and cereals together contributed about 53 % of the Zn intake in the iron recycling village, while the corresponding number in the reference village was 60 %. Only in the iron recycling village, consumption of dairy products such as milk and yoghurt was reported, and therefore in the reference village, this food category did not contribute to the Zn intake (Table 6, Figs. 10, 11).

Table 6. Food sources contributing to the Zn intake (relative distribution). Mean value and standard derivation for the whole village, for the five women with the highest Zn intake and for the women with the lowest Zn intake in the iron recycling village and the reference village, based on a typical day.

	Rice	Pulses	Leafy green vege-tables	Other vege-tables	Fruit	Meat	Tofu	Dairy
Iron recycling village - mean value of Zn intake (mg/day and person)	0.53 ±0.14	0.03 ±0.07	0.04 ±0.02	0.02 ±0.03	0.01 ±0.01	0.25 ±0.14	0.10 ±0.11	0.02 ±0.06
Iron recycling village - the five women with the highest Zn intake (mg/day and person)	0.49 ±0.16	0.02 ±0.05	0.04 ±0.03	0.03 ±0.05	0.01 ±0.01	0.29 ±0.08	0.12 ±0.17	0.00 ±0.00
Iron recycling village - the five women with the lowest Zn in-take (mg/day and person)	0.48 ±0.19	0.06 ±0.08	0.03 ±0.03	0.02 ±0.02	0.01 ±0.02	0.21 ±0.15	0.11 ±0.10	0.10 ±0.13
Reference village - mean value of Zn intake (mg/day and per-son)	0.60 ±0.11	0.03 ±0.05	0.05 ±0.03	0.01 ±0.03	0.01 ±0.01	0.23 ±0.11	0.08 ±0.06	0.00 ±0.00
Reference village - the five women with the highest Zn intake (mg/day and person)	0.56 ±0.14	0.04 ±0.08	0.04 ±0.02	0.00 ±0.00	0.01 ±0.00	0.26 ±0.10	0.09 ±0.03	0.00 ±0.00
Reference village - the five women with the lowest Zn in-take (mg/day and person)	0.58 ±0.12	0.01 ±0.02	0.05 ±0.03	0.00 ±0.01	0.00 ±0.01	0.26 ±0.16	0.10 ±0.09	0.00 ±0.00

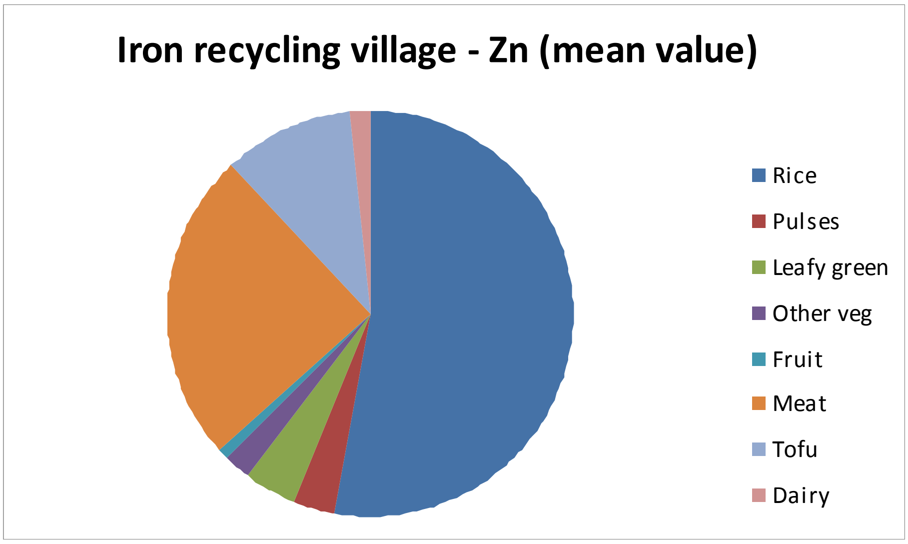

Figure 10. The contribution of the different food groups to the total Zn intake, as a mean value for the iron recycling village.

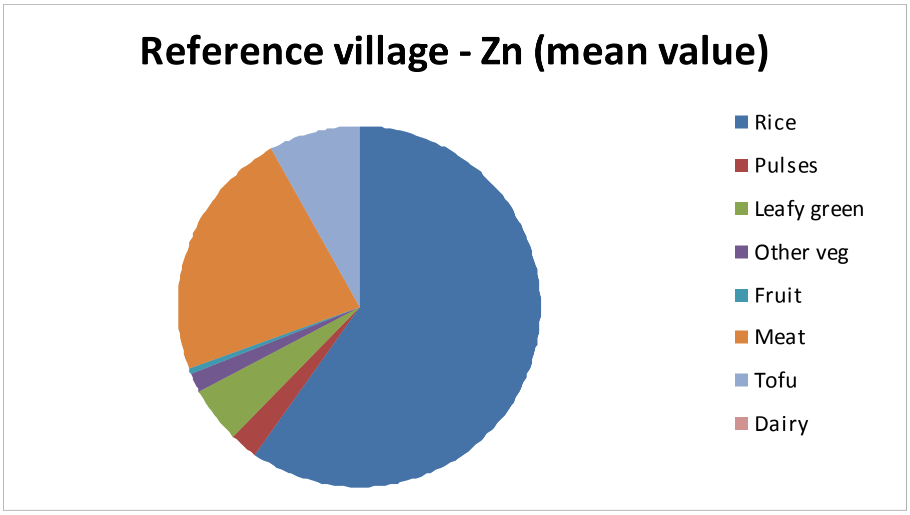

Figure 11. The contribution of the different food groups to the total Zn intake, as a mean value for the reference village.

The contributions made to the Fe intake by the different food groups also varied between the two villages. Data from the typical day tool indicated that rice, noodles, bread and cereals only contributed to 19 % of the total Fe intake in the iron recycling village, comparing to the reference village where this food group contributed 24 % of the Fe. The meat category contributed to 29 % in the iron recycling village and 21 % in the reference village. Tofu contributed to 22 % in the iron recycling village, while the corresponding number in the reference village was 19 % (Table 7, Fig. 12, 13).

Table 7. Food sources contributing to the Fe intake (relative distribution). Mean value and standard derivation for the whole village, for the five women with the highest Fe intake and for the women with the lowest Fe intake in the iron recycling village and the reference village, based on a typical day.

	Rice	Pulses	Leafy green vege-tables	Other vege-tables	Fruit	Meat	Tofu	Dairy
Iron recycling village -mean value of Fe intake (mg/day and person)	0.19 ±0.09	0.04 ±0.09	0.21 ±0.10	0.04 ±0.05	0.01 ±0.03	0.29 ±0.17	0.22 ±0.21	0.00 ±0.01
Iron recycling village - the five women with the highest Fe intake (mg/day and person)	0.13 ±0.06	0.01 ±0.03	0.27 ±0.09	0.01 ±0.01	0.01 ±0.02	0.17 ±0.12	0.39 ±0.10	0.00 ±0.00
Iron recycling village - the five women with the lowest Fe intake (mg/day and person)	0.28 ±0.16	0.05 ±0.11	0.20 ±0.12	0.08 ±0.06	0.00 ±0.00	0.26 ±0.19	0.11 ±0.26	0.01 ±0.01
Reference village - mean value of Fe intake (mg/day and per-son)	0.24 ±0.10	0.03 ±0.06	0.28 ±0.10	0.02 ±0.05	0.01 ±0.02	0.21 ±0.14	0.19 ±0.13	0.00 ±0.00
Reference village - the five women with the highest Fe intake (mg/day and person)	0.19 ±0.06	0.06 ±0.13	0.29 ±0.09	0.00 ±0.00	0.03 ±0.01	0.20 ±0.12	0.23 ±0.08	0.00 ±0.00
Reference village - the five women with the lowest Fe intake (mg/day and person)	0.38 ±0.15	0.00 ±0.00	0.33 ±0.05	0.00 ±0.00	0.01 ±0.02	0.29 ±0.17	0.00 ±0.00	0.00 ±0.00

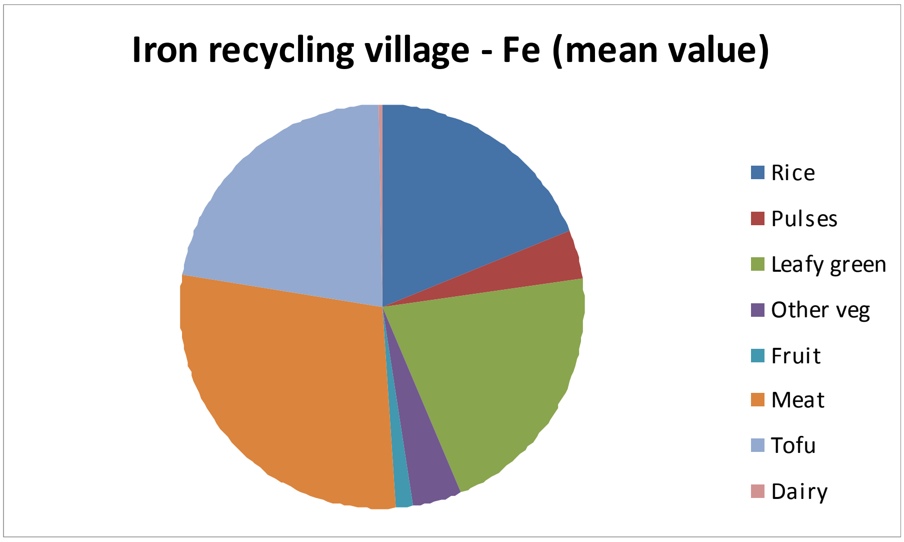

Figure 12. The contribution of the different food groups to the total Fe intake, as a mean value for the iron recycling village.

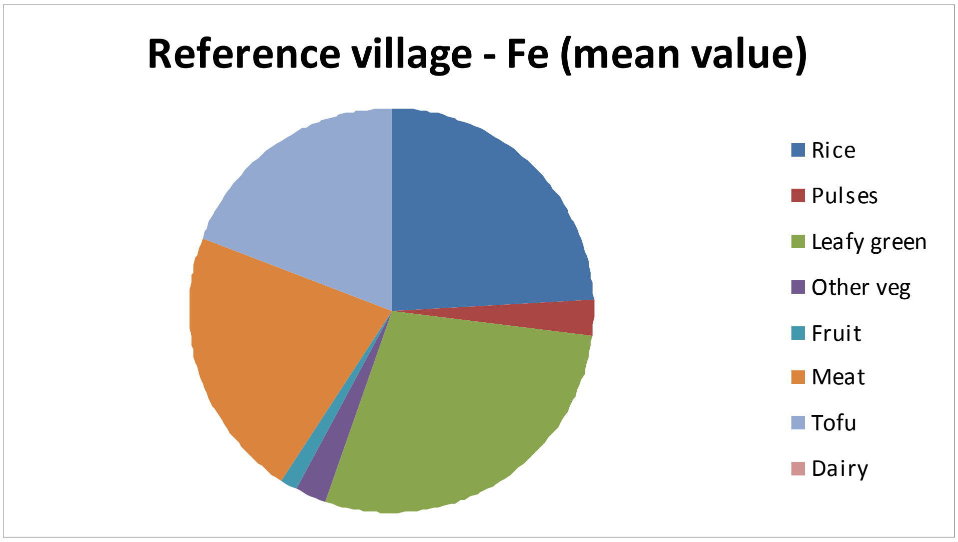

Figure 13. The contribution of the different food groups to the total Fe intake, as a mean value for the reference village.

5.2.3 Rice intake and content of Fe and Zn in rice

The average rice intake was 0.47 kg/person/day in the iron recycling village and 0.51 kg/person/day in the reference village. This difference in rice intake was not significant.

The concentration of Fe in the rice is significant higher in the reference village than in the iron recycling village. The Zn concentration in rice did not differ notably between the villages.

5.3 Anemia prevalence

Almost every one of the interviewed women (93 % in the iron recycling village and 100 % in the reference village) in the two villages had knowledge about anemia and a high proportion (79 % and 94 %, respectively) had knowledge about action programs against anemia (Table 8).

In the reference village, there was an anemia prevalence of 32 % and in the iron recycling village the proportion was 14 %. More than half of the women in the iron recycling village, 54 %, take or have taken Fe supplements. In the reference village, the corresponding number was almost 65 % (Table 8). Some of the women, that have taken Fe supplement, did this only when pregnant.

Table 8. Prevalence of anemia and knowledge about anemia and Fe supplement

	Iron recycling village (n=28) (%)	Reference village (n=31) (%)
Have knowledge about anemia	93	100
Suffering from anemia	14	32
Knowledge about action programs against anemia	79	94
Have taken Fe supplement	54	65

5.4 Food habits and food habit changes

In the iron recycling village, 57 % of the households had changed their food habits compared to five years back. In the reference village, this proportion was 95 %. The changes in dietary habits consisted of an increased intake of meat, fish and/or poultry, and in some cases also vegetables. Some households also reported more variation in the diet and better quality of the food.

The primary reason for food habit changes was for almost all households a better economy. In several households, a better knowledge about nutrition was reported as a reason. As mentioned earlier, foods rich in vitamin C, fruits for instance, can increase the non-heme Fe absorption. Based on the question about a typical day, 41% of the women reported eating fruit during this day. Guava, watermelon, mango and banana were some of the fruits reported.

5.5 Nutrition and health in Vietnam and the study areas

5.5.1 National Institute in Nutrition

National Institute in Nutrition (NIN), established in 1980 by the Vietnamese Government, belongs to the ministry of health in Vietnam, dealing with nutritional research, training and implementation activities. This includes research on food safety, dietary intake, as well as health aspects of Vietnamese foods. The Institute also suggests solutions for improving the nutritional status for the Vietnamese people, including Fe and Zn. Further, NIN works with nutritional knowledge dispersion to prevent and reduce micro nutrition deficiency and malnutrition (National Institute of Nutrition, 2010).

5.5.2 Anemia statistics in Vietnam

According to NIN, anemia mostly strikes the poor, since they do not have the same possibility to eat a sufficient amount of meat, which is one of the best Fe sources.

Although an Fe supplementation program has been implemented, 28 % of the Vietnamese women between 15 and 40 years were still considered anemic in the latest survey from National Institute of Nutrition (2004). For pregnant women, the percentage with anemia was even higher at 34 %.

NIN has had information and action programs for around 10 years. These programs include nutrient supplementing for pregnant women and de-worming. Information and education is also included, as well as enrichment of food. The information from NIN is disseminated with help of mass media and nutrition volunteers in each commune.

In Vietnam, women of reproductive age are recommended 16 Fe tablets a year and pregnant women are recommended 1 tablet a day. However, Fe supplementation is not problem-free, since many women do not take the supplement continuously. Pregnant women tend to stop take the supplements after pregnancy, even if they need to continue taking them to prevent anemia. The price for these supplements are not usually the problem, sometimes they are free of cost. (Interview with Mrs. Mai and Ms Ha at NIN, 2010)

5.6 Medical stations in the study villages

The medical stations in Vietnam are care centers were people can get help for different illnesses and diseases. In the iron recycling village and the reference village, the medical stations examined and treated medically 15 322 and 6 655 patients respectively in the year of 2009. In the iron recycling village, <10 % of the patients suffered from anemia and in the reference village, <2 % of the 16 600 commune inhabitants are estimated to suffer from anemia. However, these data are not completely comparable since everybody in the population might not visit the medical station. According to the medical station, there is a clearly correlation between anemia and socioeconomic condition.

The medical stations have different kinds of action programs, such as a reproductive health care program for pregnant women and malnutrition prevention program for children under 5 years. The stations also take part in a nationwide micronutrient implementation program, including a vitamin A program and a salt iodization program, and also a Fe/folate supplementation program that started 1996. This Fe program includes distribution of Fe tablets to women. The health information is conveyed through posters, leaflets and speakers in the streets. There is also a collaboration network including health staff and women´s union.

Concerning the costs of health care, poor households are granted health insurance cards from the government, covering 95 % of the total medical examination fees. Poor households also have the possibility to take low-interest loans from the Bank of Social Policy.

According to the medical station the prevalence of anemia has, since the program started, been reduced due to Fe supplementation programs, economic growth and improved availability of food. The rate of pregnant women using Fe tablets has also increased and the women have got a raised awareness of the benefits of Fe supplementation (Interview with Dr. Ms Nguyen Thi Thanh Huong, Vice-head of the medical station in Tu Son and Ms Dr. Ms Nguyen Thi Minh Tam - Head of the medical station in Dong Anh).

6 Discussion

6.1 Dietary intake of Fe and Zn

The average dietary intake of Fe was similar in both villages, according to both a typical day and the FFQ (Table 5). The average dietary intake of Zn based on the FFQ was similar in the villages. However, the Zn intake based on a typical day was significant higher in the reference village. Consequently, one of the hypotheses was, to some extent, not substantiated by the evidence since it included the statement that the women in the iron recycling village might have a higher Fe and Zn intake due to their off-farm income. The women in this village do not eat more foods rich in Fe and Zn or bigger amounts of foods. Though, only in the iron recycling village, dairy products were reported. Dairy products are relative expensive and this higher consumption can probably be due to higher off-farm income in this village. The reason for consuming more meat in the iron recycling village may also be due to a higher off-farm income, as also meat are expensive. There can also be differences in the nutritional knowledge levels within the villages, leading to less awareness about which foods contribute to higher Fe and Zn intake.

The Zn intake in the iron recycling village and the reference village was higher than the recommended daily allowances published by NIN, regardless if based on typical day or the FFQ tool. Also, when comparing to the Zn recommendations by WHO, regardless if looking at high, moderate or low availability, the Zn intake in the both villages was higher. According to this, the interviewed Vietnamese women reach the recommended intake of Zn. However, this assumes that the correct diet have been reported, which might not be the case, since over-reporting is a possibility. It also assumes that the nutritional composition of the food items from international databases are applicable for the Vietnamese food. A strength in this study is the access to local rice and water spinach data since that constitute the main food items consumed.

The recommended intake of Fe published by NIN is 41.3 mg/day for the age range 15-18 years and 39.2 mg/day for the age range 19-49 years (Table 2). The Fe intake in the iron recycling village is similar to the intake in the reference village. None of the villages reach the recommended intake level.

When comparing the Fe intake in the villages (Table 5) with the recommendations from WHO/FAO (Table 2), the mean Fe intake was lower in both villages. This was regardless of age group and mean body weight, as well as using the 5 or 10 % bioavailability level, levels that WHO/FAO considered realistic for developing countries.

A low Fe and Zn status increase the absorption of PTEs, such as Cd. For this reason, the Fe intake, and consequently the Fe status, need to be improved in these villages. But since the diet in Vietnam is rice-based, it is a challenge to reach the Fe recommendations. However, changes in the meal composition, can increase the Fe intake. One suggestion of composition changes can be to replace a part of the rice with for instance tofu or beef. However, such modifications of the meals is often difficult because of the economic situation within the families, and therefore problematic to implement.

When comparing the mean Fe and Zn intake values from the FFQ with the mean values from a typical day, it showed that the FFQ values were lower in both villages (Table 5). This was also expected, since all foods were not included in the FFQ table and therefore the same values are not expected to be reached.

The individual Fe and Zn values from a typical day differ a lot in some cases in comparison to the corresponding individual FFQ values. However, the mean values for the villages, do not show these large dissimilarities. The differences for the individual values can originate in over- or under-reporting both in a typical day and in the FFQ. The estimations made for the FFQ might be hard for the women to make, since it covers a whole year, which makes it difficult to recall.

In many cases, identical or very similar amounts and shares of foods were reported for the women within the same household. This might be the real circumstances, but can also be the result of a simplification when reporting the amounts and shares.

The different food groups; rice, pulses, leafy green vegetables, other vegetables, fruit, meat, tofu and dairy respectively, do not contribute to the same extent to the Fe and Zn intake in the two villages.

For the Zn intake, the rice group contributed with 53 % in the iron recycling village, which was lower than the corresponding proportion in the reference village (60 %). The Zn concentration in rice did not differ notably between the villages. There was no significant difference in the amount of consumed rice when comparing the villages. One possibility is that the inhabitants of the reference village eat smaller amounts of other food types than the inhabitants in the iron recycling village, and therefore the proportion of rice is smaller in the iron recycling village. Concerning the other food groups, that slightly differed in proportion, neither these differences can be explained by different Zn content in the specific foods, since the same values for meat, tofu, fruit and so on were used for the both villages. A low or a very low eaten amount were reported for the food groups fruits, dairy products, other vegetables and pulses, and therefore any conclusions are hard to make for these foods (Table 6).

Also for the Fe intake, in the reference village rice contributed to a larger share than it did in the iron recycling village, 24 % and 19 % respectively. The significant higher concentration of Fe in the rice in the reference village might explain this difference. Another explanation can be the same as above, that the inhabitants in the reference village have a lesser consumption of other food items than rice. Since the meat contributed to a bigger share of the total Zn intake in the iron recycling village than in the reference village, it should be similar when it comes to Fe, which was also the case (29 % and 21 % respectively) (Table 7). This may indicate a higher meat intake in the iron recycling village.

The inhabitants in both villages have similar Fe intakes, but from partly different sources. The higher relative distribution of the intake of meat and tofu in the iron recycling village, may be due to a higher off-farm income. Though, these higher intakes do not result in a significant difference for the total mean dietary intake of Fe between the villages. The relative distribution of the intake of leafy green vegetables was higher in the reference village. Leafy green vegetables are, like meat and tofu, a good source of Fe, and an alternative for the inhabitants not affording meat products. However, since meat enhance the bioavailibility of non-heme Fe, individuals eating a diet containing less meat have in general a lower absorption. For this reason, the dietary intake of Fe can be similar, but because of the differences in bioavailibility, the Fe status may differ.

Comparisons can be made within the villages, if looking at the mean value of the five women with the highest and the five with lowest intake of Fe and Zn.

For the Zn intake in the reference village, the relative share differed only slightly between the two groups of women; while in the iron recycling village the differences were more pronounced. In the group with the highest Zn intake, in the iron recycling village, the meat contributed with 29 % of the daily Zn intake, when the corresponding number in the group with the lowest intake was 21 %. However, in the group with the highest Zn intake in the iron recycling village, the dairy products contributed to a smaller share of the daily Zn intake (0 % compared to 10 %), and that was also the case for pulses (2 % instead of 6 %). These values indicated that the women in the group with the highest Zn intake consumed more meat than the women with the lowest Zn intake, but less dairy products and pulses (Table 6).

Concerning the contribution from the different food groups to the total daily Fe intake, the values in the villages differed largely, especially when it comes to rice and tofu, but also the other food groups to a certain extent.

In the iron recycling village, the rice share was more than doubled (28 % compared to only 13 %) in the group with the lowest Fe intake. The group with the lowest Fe intake also had a higher share of other vegetables (8 % compared to 1 %) and meat (26 % compared to 17 %) contributing to the intake. However, the most pronounced difference in the iron recycling village was the tofu. More than a third, 39 %, of the Fe intake in the group with the highest Fe intake came from tofu. This can be compared with 11 % in the group with the lowest Fe intake in the same village. These numbers may indicate that the group with the highest Fe intake consume a higher amount of tofu and a smaller amount of rice.

Also in the reference village, the relative share of rice was much bigger in the group with the lowest Fe intake (38 % compared with 19 %). The meat contributed to 29 % of the daily Fe intake in the group with the lowest Fe intake, while the corresponding number within the women with the highest intake is 20 %. For tofu, similarities to the iron recycling village can be seen. In the reference village, tofu contributed to 23 % of the daily Fe intake within the group of women having the highest Fe intake, and 0 % for the women with the lowest Fe intake. This may indicate a higher consumption of tofu also in the reference village, within the group of women with the highest Fe intake (Table 7). Tofu has a very high content of Fe (29.1 mg/kg fw, Appendix 2, Table A1) and together with peas and beans, intestine from chicken, duck egg and snails, tofu is in the upper part of the list for Fe rich content foods reported in a typical day.

Regarding the fruit intake, like many other foods, the type of fruits probably varies during the year, depending on season. As mentioned earlier, foods rich in Vitamin C can increase the non-heme iron absorption; it is therefore preferable to eat fruits rich in Vitamin C. However, fruit is a relatively expensive product in Vietnam, which may explain why fruit consumption is low within the study families.

Tea and other beverages were not included in the typical day in the questionnaire, since the study focused on Fe and Zn intake from food. Though, green tea is a very common drink, consumed basically every day by many Vietnamese. As mentioned before, the polyphenols in tea restrain the Fe absorption. This can affect the Fe status of the women, something which was not captured by this study as we focussed on estimating Fe and Zn intake only.

There was some discussion with the Vietnamese students and supervisors participating in this project, concerning whether bones and skin should be included or not, when calculating the Fe and Zn content in the meat. The discussion included the purchase and cooking habits, to obtain as good values as possible. This resulted in different categories for the meat; with or without bone/skin, and clarifications from the interpreters when translating the questionnaires from Vietnamese into English.

6.2 Anemia situation

The high proportion of women knowing about anemia (97 % in total) and action programs (86 % in total) shows that the information disseminated by NIN and the medical stations has reached the village population, at least to a certain extent (Table 8). In the reference village, prevalence of anemia is almost twice the rate in the iron recycling village (Table 8). The mean value for all women in both villages is 24 %. This value can be compared with 28 %, the percentage of the Vietnamese women suffering from anemia in 2004, according to NIN. However, that value might have changed since the survey was carried out. Regardless, the intake of Fe need to be increased to obtain a better Fe status, and thereby decrease the risk for anemia.

Some of the women had very low Fe intake values, and of these, a number were taking or have taken Fe supplements. This can be the reason for not reporting anemia suffering, despite a low Fe intake. It might also be the case that some of the women were suffering from anemia, without knowing it, and thus not reporting it.

6.3 Food habits changes

In the iron recycling village, a high percentage (95 %) of the households had changed their food habits compared to five years back. In the reference village, the number was 57 %. One possible reason for this, may be that the inhabitants in the iron recycling village had started to change their diet earlier than the inhabitants in the reference village and therefore saw less changes the past five years.

6.4 Possible sources of errors and alternative methods

If the study would have been repeated, there are some changes and source of errors that could be taken into consideration to improve the accuracy and reliability of the findings.

There are several potential source of errors for this study. Both over- and under-reporting is most likely, unintentional as well as intentional. Unintentional, since it can be hard to estimate eaten amounts and the shares in a typical day, but also in the FFQ over a year. Intentional, since some families might want to give the impression of eating more, or different food, than they actually do. The reported amount of food might have been incorrectly estimated, since there could have been misunderstandings concerning which parts, such as fish bones, fruit peel and fruit stones, that should be included. These errors were attempted to be eliminated with the help of the photo album used during the interviews, where pictures and weight of for instance fruits with and without peel were shown.

Some fruits and vegetables were missing in the food databases. In these cases a discussion was held with the supervisors and the most equal food was chosen as a replacement.

Both raw and cooked food were reported in the questionnaire. When raw food was reported, some nutrient losses probably occur when cooking the food. These losses has not been taken into consideration, since changes like these are difficult to estimate.

When asking about a typical day, two or more days would be preferable instead of one. This would have given a more reliable result, since the food eaten during only one day might not be fully representative. Though, considering the time limit, this was not an option.

During the interviews, the questions might have been asked in different ways. To avoid the problem with different interviewing techniques, one interview group instead of two would have been preferred.

The language difficulties were a disadvantage and it was not possible for us, as non-Vietnamese speakers, to double-check the questions during the interview, or to follow up the answers with attendant questions. The translation from Vietnamese to English, and the opposite, is another part of the work, where the language can have been a problem. Even though all translation was made in collaboration with Vietnamese students, there can still have been some misunderstandings.

In a few completed questionnaires, some items were reported as having a very large amount consumed during a typical day. For instance 400 g cucumber in the same meal for one woman, or over 600 g cooked vermicelli for breakfast for another woman. These high values were discussed and it probably had to do with incorrect estimations, either for the amount or the share. The values were outliers, but not impossible. Therefore, these values were included in the calculations.

In Vietnam, as in many other countries, seasonal variations contribute to which foods are eaten, especially when it comes to fruits and vegetables. Therefore, the Fe and Zn values obtained from a typical day probably accord better with the nutritional intake the women have in March-April, rather than for example during August or September. Consequently, seasonality in consumption was not taken into account when calculating the Fe and Zn intake based on a typical day.

In the FFQ, foods were chosen on the basis of commonly consumed food and also food rich in Fe and Zn. The answers of the women, though, might be reported without consideration of seasonality.

In some families, there was not always a possibility to interview the individual with the most information about the amount or sharing of the eaten food. On some occasions, the father or the daughters were interviewed instead of the mother, although the mother was the one cooking. Thus, the most accurate information might not always have been given.

When comparing the responses in the questionnaires from the two interview teams, a large difference was noticed regarding the intake of intestines, where one of the teams' questionnaires contained a much more frequent intake of giblets than the other team. This may be due to different food habits in the two villages or just different food habits that specific day. It may also be due to different ways of asking questions, and can therefore be a bias.

Since a question about the consumption and frequency of rice was asked for only in the iron recycling village in the FFQ (Appendix 1), the mean value based on these respondents, might not be representative for the women in the reference village. Anyhow, the value is probably fairly reliable since rice is a main staple food in Vietnam.

When asking about a typical day, in none of the households oil/fat and sauces were reported, although all foods consumed this day were asked for. This may be due to misunderstandings about what was meant to be included or not.

When comparing the FFQ table with the question about amount and frequency of food purchase, some differences were detected. The women tend to often report an either higher or lower purchase than the consumed amount in the FFQ. The implications of this may be a difference between the reported amounts and the actual ones.

Since only 59 women in total were interviewed in the two villages, it is hard to draw any conclusions representing a whole population, and even for the inhabitants in these two villages.

The food composition database used most often in this study was The National Nutrient Database of United States Department of Agriculture. This database does not contain values specified for Vietnam, neither does the other database used, The Swedish Food Database of the National Food Administration in Sweden. The results can therefore only be seen as reasonable estimations and to get a more true result, analyses need to be done for each food eaten by the women.

7 Conclusions and Recommendations

7.1 Conclusions

The dietary Fe intake, for a typical day and the FFQ, and the Zn intake for the FFQ, were similar in both villages. However, the Zn intake a typical day was higher for the women in the reference village compared to the iron recycling village. The reason for this difference is difficult to establish. One likely explanation can be that the women in the reference village consume a higher amount of food and/or different type of foods, containing more Zn. The knowledge about nutrition in the two villages might also differ, which may contribute to the choice of food types.

The dietary sources of Fe and Zn differed between the villages. Leafy green vegetables contributed more to the total Fe and Zn intake in the reference village than in the iron recycling village, where instead meat and tofu constituted a larger relative share. Despite a similar intake, the dietary sources can differ, and thereby the Fe and Zn bioavailibility varies.

The intake of Zn for the women in both study villages reach the recommendations by National Institute of Nutrition (NIN), as well as the recommendations by World Health Organization (WHO). The hypothesis that the Zn intake in the villages was below the recommendations, was consequently not substantiated by the evidence. However, the hypothesis about the Fe intake was supported. The intake of Fe in both villages was lower than the recommended value, regardless if comparing with the recommendations by NIN or by WHO/Food and Agriculture Organization (FAO). Since low Fe and Zn status affect the uptake of PTEs, like Cd from metal recycling activities, it is important to get enough of these nutrients. Furthermore, it is of major importance to have a adequate Fe status, since Fe deficiency is a common cause for anemia. In the iron recycling village, 14 % reported they suffer from anemia and in the reference village, 32 % suffered from anemia. This indicates that the situation need to be improved. If the information about anemia was even more wide-spread and the economic situation within the households was better, the possibilities to improving the health status would be increased.

7.2 Recommendations

7.2.1 Improving Fe and Zn intake and absorption

The Fe and Zn intake can be increased by changing the diet. The Fe content is high in for instance tofu, intestines, eggs, beef and some green leafy vegetables. A higher intake of these foods will therefore increase the Fe intake. Meat, fish, intestine, but also egg, contains a high amount of Zn, and consequently, consuming more of these foods will result in a higher Zn intake (Abrahamsson *et al*., 2006).

By modifications of the diet, the absorption of Fe can be increased. Consuming a larger amount of food enhancing Fe absorption increase the bioavailability of the Fe in the diet. Foods enhancing the absorption of nonheme iron are for instance meat and ascorbic acid. Also consuming smaller amounts of foods inhibiting Fe absorption will give a higher Fe absorption (Commission of the European Communities,1993).

7.2.2 Other strategies to improve Fe and Zn nutrition

NIN already works with improving the nutritional status for the Vietnamese people, and clear and adequate information is of course very important for spreading knowledge about nutrition. For the same reason, it is also of big importance that the medical stations continue with helping and informing about nutrition and when needed also helping with Fe supplementing.

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Acknowledgement

We would like to thank our supervisor in Sweden, Professor Ingrid Öborn, Department of Crop Production Ecology, who has been indispensable through this project.

We sincerely express our thanks to our supervisors Dr Nguyen Cong Vinh and Mr Ngo Duc Minh at Soil and Fertilizers Research Institute (SFRI) in Hanoi, Vietnam, whom have been very helpful and with all the practical arrangements in field, as well as the calculations and translations. Thanks also to Dr Rupert Hough, The James Hutton Institute, UK, who have helped a lot with the Access database and other already existing data, translations and problematic issues.

Thanks to the Vietnamese students Chi Tuong and Tuyen Tran, Hanoi University of Sciences and Technology, Vietnam, whom have been very valuable during the interviews and the following translation. We also would like to thank Carin Sjöstedt, PhD student, KTH, Sweden, that have helped improving the questionnaire and providing useful data.

Thanks to Mrs. Mai and Ms Ha at National Institute of Nutrition (NIN) for sharing valuable knowledge with us and for helping with the questionnaire and providing adequate information. We also would like to express our thanks to the medical stations in Dong Anh and Tu Son.

Finally, our great thanks to the households and women in the study villages for valuable participation in the study and for sharing knowledge and experience with us.

This study was funded through the Sida Minor Field Study scholarship programme and the Sida Research Council supported project SWE-2008-265.

Appendix 1

Village/hamlet ....Commune...................District.........................Province.................... .

Household information

Household code: ________________________

Head family name: ______________________

Number of members in the family: _________

Number of children (0-14 years old) in the household: _______

	Children 1	Children 2	Children 3	Children 4	Children 5	Children 6	Children 7
Gender and age:							

Personal information (individual female from 15-40 year olds)

Female 1 (F1), Name: ______________________________ Age: _______Height (cm): ________ Weight (kg): ________

Female 2 (F2), Name: ______________________________ Age: _______Height (cm): ________ Weight (kg): ________

Female 3 (F3), Name: ______________________________ Age: _______Height (cm): ________ Weight (kg): ________

Interviews have been performed in this household earlier. Which one of the females where at home then, at that time?

____

Village/hamlet ....Commune...................District.........................Province.................... .

FOOD A NORMAL DAY - for whole family/household

What did your household eat yesterday (if yesterday was a normal day)? If yesterday was not a normal day – what does your household eat a normal day?

Meal (breakfast/lunch /dinner /other)	Food type*	Specify information of food			Consumed food by whole family (kg or g)	Raw (1) / cooked weight (2)?	The source of rice**	Share for each female (% or g)		
		Name	Amount	Weight (g)				F1	F2	F3

* = Eg. Rice, vegetable, root/tuber, beef, pork, chicken, fish, tofu, egg, milk, water, fruit

Village/hamlet ....Commune...................District.........................Province.................... .

: **[1]. grown/raised on their farm, **[2].** local (village) market, **[3].** other market (town/city), **[4].** other source

FFQ (frequency and amount for every food) – for individual

Food	Frequency (average times)												How much food do whole family eat every meal ?(g/kg)	When eating – how much percent do you eat then (in average)?			Given amount is in raw (1) or cooked (2) food
	How many **times per day** did the family eat .... ?			How many **times per week** did the family eat .... ?			How many **times per month** did the family eat .... ?			How many **times per year** did the family eat .... ?							
	F1	*F2*	*F3*	*F1*	*F2*	*F3*	*F1*	*F2*	*F3*	*F1*	*F2*	*F3*		*F1*	*F2*	*F3*	
Chicken or duck																	
Beef or buffalo																	
Pork																	
Dog																	
Fish																	
Liver																	
Kidney																	
Stomach																	
Heart																	
Blood food																	
All intestines from chicken or duck (in the same meal)																	

Village/hamlet ....Commune...................District.........................Province..................... .

Food	Frequency (average times)												How much food do whole family eat every meal ?(g/kg)	When eating – how much percent do you eat then (in average)?			Given amount is in raw (1) or cooked (2) food
	How many **times per day** did the family eat .... ?			How many **times per week** did the family eat .... ?			How many **times per month** did the family eat .... ?			How many **times per year** did the family eat .... ?							
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3		F1	F2	F3	
Egg (chicken, duck, bird...)																	
Tofu																	
Water spinach																	
Sweet potato leaves																	
Sauropus, leaves																	
Pumpkin leaves																	
Mustard greens																	
Amaranth																	
Tomato																	
Mungobean sprout																	
Winged Jam																	
Taro tuber																	

Village/hamlet ....Commune...................District.........................Province.................... .

Food	Frequency (average times)												How much food do whole family eat every meal ?(g/kg)	When eating – how much percent do you eat then (in average)?			Given amount is in raw (1) or cooked (2) food
	How many **times per day** did the family eat .... ?			How many **times per week** did the family eat .... ?			How many **times per month** did the family eat .... ?			How many **times per year** did the family eat .... ?							
	F1	*F2*	*F3*	*F1*	*F2*	*F3*	*F1*	*F2*	*F3*	*F1*	*F2*	*F3*		*F1*	*F2*	*F3*	
Potato, white																	
Other vegetables/roots: 1. ________________ 2. ________________																	
Peanuts																	
Banana																	
Pineapple																	
Guava common																	
Water melon																	
Apple																	
Papaya																	

Village/hamlet ....Commune....................District..........................Province..................... .

When you eat intestines – do you eat it instead of meat/chicken/fish/seafood/eggs/tofu, or do you eat it at the same meal?

When you eat eggs – do you eat it instead of meat/chicken/fish/seafood/intestines/tofu, or do you eat it at the same meal?

When you eat tofu – do you eat it instead of meat/chicken/fish/seafood/intestines/eggs, or do you eat it at the same meal?

BUYING FOOD - For household

Type of animal	Whole animal / What part	How many kg per each time do you buy (in average)?	How often do you buy it?
Chicken			
Fish			
Pig			
Cow and buffalo			

Village/hamlet ....Commune...................District.........................Province.................... .

CHANGING OVER TIME – for the household

Have your food habits changed if you compare to 5 years back? If yes, what is different? (For example, if you eat more meat now than before)

Why has it changed? (For example, if their economic situation has improved or if someone has told them more about nutrition and health)

ANEMIA – for the individual

Questions (yes or no)	Female 1	Female 2	Female 3
Have you heard about anemia?			
If yes, do you suffer from anemia?			
If yes, do you know there are action programs against anemia?			
Have you ever taken any iron supplement?			

Appendix 2

Table A1. Zn and Fe concentration values of the food type present in the questionnaire (typical day and FFQ)

Type of food from questionnaire	Food name in the database	Zn (mg/kg fw)	Fe (mg/kg fw)	Source
Rice/noodles				
Rice noodles, cooked	Rice noodles, cooked	2.5	1.4	USDA
Rice noodles, raw	Rice noodles, dry	7.4	7.0	USDA
Rice, raw (Chau Khe, Tu Son)	Rice (polished, 2007)	19.5	5.2	Sida Project Database
Rice, raw (Co Loa, Dong Anh)	Rice (polished, 2008)	20.0	6.0	Sida Project Database
Rice, cooked/fried (Chau Khe, Tu Son)	Rice (polished, 2007) - calculated by a conversion table (Table A4)	8.9	2.4	Sida Project Database
Rice, cooked/fried (Co Loa, Dong Anh)	Rice (polished, 2008) - calculated by a conversion table (Table A4)	9.1	2.7	Sida Project Database
Vermicelli, cooked	Rice noodles, cooked	2.5	1.4	USDA
Vermicelli, raw	Rice noodles, dry	7.4	7.0	USDA
Rice pudding	Puddings, rice, ready-to-eat	4.9	1.1	USDA
Instant noodles, wheat, raw	Soup, ramen noodle, any flavor, dry	8.5	4.0	USDA
Sticky rice (glutinous rice), cooked	Rice, white, glutinous, cooked	4.1	1.4	USDA
Sticky rice (glutinous rice), raw	Rice, white, glutinous, raw	1.2	1.6	USDA
Vegetables and tubers				
Amaranth leaves, boiled	Amaranth leaves, cooked, boiled, drained, with salt	8.8	22.6	USDA
Amaranth leaves, raw	Amaranth leaves, raw	9.0	23.2	USDA
Beans, kidney, in pod, french bean: navybean, stir fried	Beans, french, mature seeds, cooked, boiled, with salt	6.4	10.8	USDA
Beans, kidney, in pod, french bean: navybean, raw	Beans, french, mature seeds, raw	19.0	34.0	USDA
Cow peas, Chinese bean, boiled	Beans, french, mature seeds, cooked, boiled, with salt	6.4	10.8	USDA

Cow peas, Chinese bean, raw	Beans, french, mature seeds, raw	19.0	34.0	USDA
Cabbage, common, raw	Cabbage, common (danish, domestic, and pointed types), freshly harvest, raw	1.8	5.6	USDA
Cabbage, chinese, boiled, raw	Cabbage, chinese (pak-choi), raw	1.9	8.0	USDA
Calabash, bottle gourd, raw	Gourd, white-flowered (calabash), raw	7.0	2.0	USDA
Calabash, bottle gourd, soup, raw	Gourd, white-flowered (calabash), raw	7.0	2.0	USDA
Carrot	Carrots, raw	2.4	3.0	USDA
Celery water, raw	Celery, raw	1.3	2.0	USDA
Corn, raw	Corn, sweet, yellow, raw	4.6	5.2	USDA
Corn, boiled	Corn, sweet, yellow, cooked, boiled, drained, without salt	6.2	4.5	USDA
Cress, sp., raw	Cress, garden, raw	2.3	13.0	USDA
Cucumber, raw	Cucumber, peeled, raw	1.7	2.2	USDA
Eggplant, raw	Eggplant, raw	1.6	2.4	USDA
Eggplant small, cooked (pickled)	Eggplant, pickled	2.3	7.7	USDA
Eggplant, cooked or stir fried	Eggplant, cooked, boiled, drained, with salt	1.2	2.5	USDA
Eggplant, salted	Eggplant, pickled	2.3	7.7	USDA
French bean	Beans, Danish, mature seeds, raw	19.0	34.0	USDA
Gourd, Sponge gourd, raw	Gourd, dishcloth (towelgourd), raw	0.7	3.6	USDA
Kohlrabbi	Kohlrabi, raw	0.3	4.0	USDA
Mungo bean sprout, raw	Mungbönsgroddar (mungo bean sprout)	4.0	9.0	SLV
Mungo bean sprout, canned	Mungbönsgroddar konserv u lag (mungo bean sprout, canned)	2.0	4.0	SLV
Mungo bean, cooked	Mung beans, mature seeds, cooked, boiled, without salt	8.4	14.0	USDA
Mungo bean, raw	Mungo beans, mature seeds, raw	33.5	75.7	USDA
Mustard greens, raw	Mustard greens, raw	2.0	14.6	USDA
Mustard greens, boiled/stir fried	Mustard greens, cooked, boiled, drained, with salt	1.1	7.0	USDA
Mustard greens, salted, raw	Mustard greens, raw	2.0	14.6	USDA
Mustard greens, salted, boiled (vår idé)	Mustard greens, cooked, boiled, drained, with salt	1.1	7.0	USDA

Mustard greens, India (leaves and stams)	Mustard greens, raw	2.0	14.6	USDA
Peanuts	Peanuts, all types, dry-roasted, with salt	33.1	22.6	USDA
Pumpkin leaves, raw	Pumpkin leaves, raw	2.0	22.2	USDA
Radish white, raw	Radishes, raw	2.8	3.4	USDA
Rape bird (brassica rapa), cooked/stir fried	Mustard greens, cooked, boiled, drained, with salt	1.1	7.0	USDA
Rape bird (brassica rapa), raw	Mustard greens, raw	2.0	14.6	USDA
Sauropus, sp. leaves	Mean value for amaranth leaves, mustard greens, waterspinach, vine spinach (all raw)	4.3	14.8	USDA, Sida Project Database
Su su (chayote) leaves, raw	Pumpkin leaves, raw	2.0	22.2	USDA
Sweet potato leaves, raw	Sweet potato leaves, raw	2.9	10.1	USDA
Taro tuber	Taro, raw	2.3	5.5	USDA
Tomato, raw	Tomatoes, red, ripe, raw, year round average	1.7	2.7	USDA
Vine spinach	Vinespinach, (basella), raw	4.3	12.0	USDA
Waterspinach, raw (Chau Khe)	Mean value of waterspinach from Chau Khe	2.0	9.5	Sida Project Database
Waterspinach, raw (Co Loa)	Mean value of waterspinach from Chau Khe	2.0	9.5	Sida Project Database
Winged yam	Yam, raw	2.4	5.4	USDA
Wintermelon	Squash, summer, zucchini, includes skin, raw	3.2	3.7	USDA
Potato	Potatoes, white, flesh and skin, raw	2.9	5.2	USDA
Fruit				
Apple	Apples, raw, without skin	0.5	0.7	USDA
Bell fruit (japanese plum enl. NIN)	Rose-apples, raw	0.6	0.7	USDA
Banana	Bananas, raw	1.5	2.6	USDA
Cluster fig, raw	Figs, raw	1.5	3.7	USDA
Cluster fig, cooked	Figs, raw	1.5	3.7	USDA
Guava, common	Guavas, common, raw	2.3	2.6	USDA
Mango	Mangos, raw	0.9	1.6	USDA
Melon, Cantaloupe	Melons, cantaloupe, raw	1.8	2.1	USDA
Papaya	Papayas, raw	0.8	2.5	USDA
Pineapple	Pineapple, raw, all varieties	1.2	2.9	USDA

Plum	Plum, raw	1.0	1.7	USDA
Water melon	Watermelon, raw	1.0	2.4	USDA
Meat				
Beef without bones, raw	Beef, composite of trimmed retail cuts, separable lean and fat, trimmed to 1/8" fat, all grades, raw	37.5	19.1	USDA
Dog, raw	Pork, fresh, composite of trimmed retail cuts (loin and shoulder blade), separable lean and fat, raw	20.1	7.4	USDA
Dog, cooked	Pork, fresh, composite of trimmed retail cuts (loin and shoulder blade), separable lean and fat, cooked	25.6	9.3	USDA
Pork, boiled/stir fried/braised	Pork, fresh, composite of trimmed retail cuts (loin and shoulder blade), separable lean and fat, cooked	25.6	9.3	USDA
Pork	Pork, fresh, composite of trimmed retail cuts (loin and shoulder blade), separable lean and fat, raw	20.1	7.4	USDA
Pork, meat ball	Köttbullar grisfärs stekta (meatballs, pork, fried)	32.1	12.2	SLV
Pork, mince fat meat grilled, cooked	Pork, ground, 72% lean / 28% fat, cooked, pan-broiled	24.8	12.1	USDA
Pork, mince fat meat grilled, raw	Pork, ground, 72% lean / 28% fat, raw	18.9	9.0	USDA
Pork, minced meat	Pork, ground, 72% lean / 28% fat, raw	18.9	9.0	USDA
Pork luncheon	Luncheon meat, pork, canned	14.8	7.2	USDA
Chicken/duck				
Chicken with bone, boiled	Mean value, roasted chicken parts (Table A2)	21.3	13.8	USDA
Chicken wings, stir fried	Chicken, broilers or fryers, wing, meat and skin, raw	13.3	9.5	USDA
Chicken with bone, raw	Mean value, raw chicken parts (Table A3)	14.6	10.4	USDA
Chicken or duck – raw	Mean value of “duck, domesticated, meat and skin, raw” and chicken (raw), (Table A3)	14.1	17.2	USDA
Chicken or duck – cooked	Mean value of “duck, domesticated, meat and skin,	20.0	20.4	USDA

	cooked, roasted" and chicken (cooked, roasted), (Table A2)			
Goose, raw	Goose, domesticated, meat and skin, raw	17.2	25.0	USDA
Goose, grilled	Goose, domesticated, meat and skin, cooked, roasted	26.2	28.3	USDA
Intestine				
Bloodfood	Blod från gris (blood from pig)	3.0	395.0	SLV
Heart – raw	Pork, fresh, variety meats and by-products, heart, raw	28.0	46.8	USDA
Heart – cooked	Pork, fresh, variety meats and by-products, heart, cooked, braised	30.9	58.3	USDA
Intestine from chicken	Chicken, broilers or fryers, giblets, raw	33.2	58.6	USDA
Kidney	Pork, fresh, variety meats and by-products, kidneys, raw	27.5	48.9	USDA
Liver	Pork, fresh, variety meats and by-products, liver, raw	57.6	233.0	USDA
Stomach	Pork, fresh, variety meats and by-products, stomach, raw	18.5	10.1	USDA
Egg				
Duck egg, boiled/steamed	Egg, duck, whole, fresh, raw	14.1	38.5	USDA
Duck egg, raw	Egg, duck, whole, fresh, raw	14.1	38.5	USDA
Egg, raw	Egg, whole, raw, fresh	12.9	17.5	USDA
Egg, fried/stir fried (except raw and boiled egg)	Egg, whole, cooked, fried	13.9	18.9	USDA
Egg, boiled	Egg, whole, cooked, hard-boiled	10.5	11.9	USDA
Egg, raw, mean value	Mean value of duck egg and hen egg (both fresh and raw)	13.5	28.0	USDA
Tofu				
Tofu	Mean value of different tofu, Table A5	12.9	29.1	USDA
Tofu, fried/stir fried	Mean value of different tofu, Table A5	12.9	29.1	USDA
Fish and seafood				
Snail	Mollusks, snail, raw	10.0	35.0	USDA

Snail, cooked	Mollusks, snail, raw	10.0	35.0	USDA
Crab, raw	Crustaceans, crab, blue, raw	35.4	7.4	USDA
Crab, cooked	Crustaceans, crab, blue, cooked, moist heat	38.1	5.0	USDA
Fish, tilapia	Fish, tilapia, raw	3.3	5.6	USDA
Fish, all except tilapia	Fish, carp, raw	14.8	12.4	USDA
Fish soup	Fish, carp, cooked, dry heat	19.0	15.9	USDA
Fish, braised/boiled/fried/stir fried	Fish, carp, cooked, dry heat	19.0	15.9	USDA
Fish (seawater), salted, not dried	Fish, carp, cooked, dry heat	19.0	15.9	USDA
Shrimps, stir fried	Crustaceans, shrimp, mixed species, raw	9.7	2.1	USDA
Milk and yoghurt				
Milk, UHT, sweetened	Milk, producer, fluid, 3.7% milkfat	3.8	0.5	USDA
Milk, dried, whole powder	Milk, dry, whole, without added vitamin D	33.4	4.7	USDA
Yoghurt, sweetened	Yogurt, plain, whole milk, 8 grams protein per 8 ounce	5.9	0.5	USDA
Bread, cookies, sweets etc				
Bread	Vitt bröd vatten typ franska fibrer ca 3% (bread, white, french, fibre content 3 %)	8.5	6.4	SLV
Peanut, stir fried	Peanuts, all types, dry-roasted, with salt	33.1	22.6	USDA
Sticky rice cake	Calculation of 80 % sticky rice and 10 % mungo bean	7.2	4.2	USDA

Table A2. Mean value of chicken with bone, boiled

Food name in the database	Fe (mg/kg fw)	Zn (mg/kg fw)
Chicken, broilers or fryers, back, meat and skin, cooked, roasted	14.2	22.5
Chicken, broilers or fryers, breast, meat and skin, cooked, roasted	10.7	10.2
Chicken, broilers or fryers, dark meat, meat and skin, cooked, roasted	13.6	24.9
Chicken, broilers or fryers, drumstick, meat and skin, cooked, roasted	13.3	28.7
Chicken, broilers or fryers, leg, meat and skin, cooked, roasted	13.3	26
Chicken, broilers or fryers, light meat, meat and skin, cooked, roasted	11.4	12.3
Chicken, broilers or fryers, neck, meat and skin, cooked, fried, batter	21.5	25
Chicken, broilers or fryers, thigh, meat and skin, cooked, roasted	13.4	23.6
Chicken, broilers or fryers, wing, meat and skin, cooked, roasted	12.7	18.2
Mean value	13.8	21.3

Source: (USDA, 2011)

Table A3. Mean value of chicken with bone, raw

	Fe (mg/kg fw)	Zn (mg/kg fw)
Chicken, broilers or fryers, back, meat and skin, raw	9.4	12.6
Chicken, broilers or fryers, breast, meat and skin, raw	7.4	8
Chicken, broilers or fryers, dark meat, meat and skin, raw	9.8	15.8
Chicken, broilers or fryers, drumstick, meat and skin, raw	10.3	20
Chicken, broilers or fryers, leg, meat and skin, raw	10.1	17.7
Chicken, broilers or fryers, light meat, meat and skin, raw	7.9	9.3
Chicken, broilers or fryers, neck, meat and skin, raw	19	18.6
Chicken, broilers or fryers, thigh, meat and skin, raw	9.9	16
Chicken, broilers or fryers, wing, meat and skin, raw	9.5	13.3
Mean value	10.4	14.6

Source: (USDA, 2011)

Table A4. Ratio of uncooked rice and cooked rice

	uncooked rice	cooked rice
Sample 1 (g)	450	930
Sample 2 (g)	480	1050
Sample 3 (g)	380	850
Sample 4 (g)	400	850
Sample 5 (g)	490	1130
Mean value (g)	440	962
Weight (g)	1000	2186
Weight (kg)	1	2.186

Source: (Dr Vinh, SFRI, 2010)

Table A5. Mean value of tofu

	Fe (mg/kg fw)	Zn (mg/kg fw)
Tofu, firm, prepared with calcium sulfate and magnesium chloride (nigari)	16.1	8.3
Tofu, fried, prepared with calcium sulfate	48.7	19.9
Tofu, hard, prepared with nigari	27.5	16.6
Tofu, raw, firm, prepared with calcium sulfate	26.6	15.7
Tofu, raw, regular, prepared with calcium sulfate	53.6	8
Tofu, salted and fermented (fuyu), prepared with calcium sulfate	19.8	15.6
Tofu, soft, prepared with calcium sulfate and magnesium chloride (nigari)	11.1	6.4
Mean value	29.1	12.9

Source: (USDA, 2011)

Table A6. Fe and Zn values for raw(un-cooked) polished rice in the iron recycling village(n=30) and the reference village (n=16)

Village	Code of sample	Fe (mg/kg)	Zn (mg/kg)
Iron recycling village	Sarec 61-07	6.13	22.70
Iron recycling village	Sarec 62-07	4.78	16.55
Iron recycling village	Sarec 63-07	4.95	22.10
Iron recycling village	Sarec 64-07	4.19	18.04
Iron recycling village	Sarec 65-07	4.95	17.73
Iron recycling village	Sarec 66-07	5.32	19.36
Iron recycling village	Sarec 67-07	4.15	16.37
Iron recycling village	Sarec 68-07	8.67	19.60
Iron recycling village	Sarec 69-07	4.51	19.85
Iron recycling village	Sarec 70-07	5.21	23.60
Iron recycling village	Sarec 71-07	7.62	21.60
Iron recycling village	Sarec 72-07	5.73	21.61
Iron recycling village	Sarec 73-07	5.23	22.46
Iron recycling village	Sarec 74-07	5.58	24.17
Iron recycling village	Sarec 75-07	4.66	21.07
Iron recycling village	Sarec 76-07	5.45	12.67
Iron recycling village	Sarec 77-07	4.77	20.07
Iron recycling village	Sarec 78-07	4.95	16.76
Iron recycling village	Sarec 79-07	5.85	20.07
Iron recycling village	Sarec 80-07	6.22	20.99
Iron recycling village	Sarec 81-07	5.52	20.14
Iron recycling village	Sarec 82-07	4.24	15.07
Iron recycling village	Sarec 83-07	4.97	19.50
Iron recycling village	Sarec 84-07	4.61	19.90
Iron recycling village	Sarec 85-07	4.71	20.08
Iron recycling village	Sarec 86-07	5.26	22.12
Iron recycling village	Sarec 87-07	5.36	17.15
Iron recycling village	Sarec 88-07	4.83	16.73
Iron recycling village	Sarec 89-07	4.47	18.44
Iron recycling village	Sarec 90-07	4.39	18.10
Reference village	Sarec 1..08	6.5	21.0
Reference village	Sarec 2..08	6.4	20.1
Reference village	Sarec 3..08	5.6	21.2
Reference village	Sarec 4..08	6.7	21.4
Reference village	Sarec 5..08	6.1	19.3
Reference village	Sarec 6..08	5.4	20.0

Reference village	Sarec 7..08	6.5	20.0
Reference village	Sarec 8..08	5.7	21.7
Reference village	Sarec 9..08	6.0	19.0
Reference village	Sarec10..08	4.8	15.3
Reference village	Sarec11..08	4.0	21.4
Reference village	Sarec12..08	5.4	18.4
Reference village	Sarec13..08	6.7	18.8
Reference village	Sarec14..08	7.6	21.3
Reference village	Sarec15..08	5.8	20.0
Reference village	Sarec16..08	6.3	20.5
Iron recycling village	Mean value	5.24	19.49
Iron recycling village	St dev	0.967	2.63
Iron recycling village	Min	4.15	12.67
Iron recycling village	Max	8.67	24.17
Reference village	Mean value	6.0	20.0
Reference village	St dev	0.846	1.61
Reference village	Min	4.0	15.3
Reference village	Max	7.6	21.7

Source: Rice (polished, 2007/2008), Sida Project Database

Table A7. Individual information about anemia and Fe supplement

Household	Female	Age	Have you heard about anemia?	If yes, do you suffer from anemia?	Do you know if there are any action programs against anemia?	Have you ever taken any Fe supplement?
CL	F1	38	Y	N	Y	Y (when pregnant)
CL	F2	18	Y	N	Y	N
CL	F3	16	Y	N	N	N
CL 01	F1	27	Y	N	Y	N
CL 01	F2	26	Y	N	Y	Y (when pregnant)
CL 02	F1	40	Y	Y	Y	Y
CL 02	F2	20	Y	N	Y	N
CL 06	F1	43	Y	N	Y	Y
CL 06	F2	19	Y	Y	Y	Y
CL 06	F3	15	Y	N	Y	N
CL 06	F4	15	Y	N	Y	N
CL 07	F1	23	Y	N	Y	Y
CL 08	F1	30	Y	Y	Y	Y
CL 09	F1	32	Y	Y	Y	Y
CL 11	F1	39	Y	N	Y	Y
CL 11	F2	21	Y	N	Y	Y
CL12	F1	28	Y	N	Y	N
CL12	F2	23	Y	N	Y	N
CL 13	F1	45	Y	N	Y	Y
CL 13	F2	23	Y	N	Y	N
CL15	F1	24	Y	Y	Y	Y (when pregnant)
CL16	F1	20	Y	N	Y	Y (when pregnant and after)
CL18	F1	36	Y	Y	Y	Y (when pregnant)
CL19	F1	39	Y	Y	Y	N
CL 21	F1	23	Y	N	Y	N
CL 22	F1	29	Y	Y (when pregnant)	Y	Y (when pregnant)
CL 22	F2	27	Y	Y (when pregnant)	Y	Y (when pregnant)
CL23	F1	26	Y	N	Y	Y (when she got married, when she got pregnant and also after the pregnancy)
CL24	F1		Y	N	N	Y (when pregnant)
CL 27	F1	29	Y	Y	Y	Y
CL 27	F2	22	Y	N	Y	Y (when pregnant)

CK 02	F1	43	Y	N	Y	Y (when pregnant)
CK 02	F2	15	Y	N	Y	N
CK 10	F1	39	Y	N	Y	N
CK13	F1	16	Y	N	Y	N
CK16	F1	45	Y	N	Y	N
CK16	F2	16	Y	N	N	N
CK 17	F1	31	Y	N	Y	Y (when pregnant)
CK 17	F2	25	Y	N	Y	Y (when pregnant)
CK 18	F1	32	Y	N	Y	Y (when pregnant)
CK 18	F2	21	Y	N	Y	Y (when pregnant)
CK 23	F1	25	Y	N	Y	Y (when pregnant)
CK24	F1	44	Y	N	N	Y (3 years ago)
CK24	F2	19	Y	N	Y	N
CK25	F1	28	Y	Y	Y	Y (when pregnant)
CK28	F1	18	Y	N	N	N
CK 29	F1	35	Y	N	Y	N
CK 30	F1	37	Y	N	Y	N
CK 30	F2	34	Y	N	Y	Y (when pregnant)
CK36	F1	40	Y	N	N	N
CK 42	F1	35	Y	N	Y	Y (when pregnant)
CK 45	F1	18	Y	N	Y	N
CK 48	F1	29	Y	Y	Y	Y (when pregnant)
CK 49	F1		Y	Y	Y	Y
CK52	F1	35	Y	N	Y	Y (when pregnant)
CK53	F1	34	Y	Y	Y	Y (when pregnant)
CK54	F1	23	N	N	N	N
CK54	F2	21	N	N	N	N
CK55	F1	23	Y	N	Y	Y (when pregnant)

Source: The household questionnaires

Table A8. Fe intake connected to anemia prevalence, iron recycling village

Housecode	Female	Fe intake/day (mg/day/person), based on typical day	Fe intake/day (mg/day/person), based on FFQ	Suffer from anemia
CK02	F1	11.31	15.46	N
CK02	F2	13.62	15.48	N
CK10	F1	5.22	14.49	N
CK13	F1	16.2	13.76	N
CK16	F1	13.96	11.09	N
CK16	F2	15.11	11.90	N
CK17	F1	11.8	7.21	N
CK17	F2	11.14	7.21	N
CK18	F1	15.76	10.00	N
CK18	F2	14.91	9.94	N
CK23	F1	10.6	11.65	N
CK24	F1	11.01	8.34	N
CK24	F2	13.79	9.39	N
CK25	F1	13.51	5.96	Y
CK28	F1	8.43	6.37	N
CK29	F1	10.58	9.92	N
CK30	F1	10.88	9.60	N
CK30	F2	11.97	9.60	N
CK36	F1	9.05	14.60	N
CK42	F1	27.55	28.27	N
CK45	F1	4.48	5.05	N
CK48	F1	6.14	13.08	Y
CK49	F1	6.38	3.98	Y
CK52	F1	8.24	10.36	N
CK53	F1	9.17	16.48	Y
CK54	F1	13.73	11.28	N
CK54	F2	13.73	11.28	N
CK55	F1	10.97	8.18	N

Source: The household questionnaires

Table A9. Fe intake connected to anemia prevalence, reference village

Housecode	Female	Fe intake/day (mg/day/person) based on typical day	Fe intake/day (mg/day/person) based on FFQ	Suffer from anemia
CL	F1	15.18	16.02	N
CL	F2	12.34	14.3	N
CL	F3	11.93	14.89	N
CL01	F1	6.18	5.47	N
CL01	F2	7.19	5.47	N
CL02	F1	17.96	9.01	Y
CL02	F2	10.8	6.8	N
CL06	F1	13.85	9.9	N
CL06	F2	12.94	10.12	Y
CL06	F3	16.2	13.84	N
CL06	F4	16.2	13.84	N
CL07	F2	11.63	5.62	N
CL08	F1	7.47	8.99	Y
CL09	F1	15.26	8.53	Y
CL11	F1	9.78	15.96	N
CL11	F2	3.98	12.71	N
CL12	F1	14.7	15.04	N
CL12	F2	15.59	17.57	N
CL13	F1	13.54	20.71	N
CL13	F2	11.42	20.98	N
CL15	F1	10.71	9.68	Y
CL16	F1	23.29	29.99	N
CL18	F1	19.63	10.13	Y
CL19	F1	13.53	19.21	Y
CL21	F1	11.82	13.35	N
CL22	F1	18.25	10.43	Y
CL22	F2	21.19	10.53	Y
CL23	F1	7.43	13.44	N
CL24	F1	10.61	11.14	N
CL27	F1	14.07	15.65	Y
CL27	F2	13.56	13.08	N

Source: The household questionnaires

Table A10. Food habit changes in the iron recycling village, compared to five years back

Housecode	Food habit changes	Kind of changes	Reasons for the changes
CK02	N		
CK10	N		
CK13	Y	More fish and better quality of the food	Better economy
CK16	Y	More meat and fish	Better economy
CK17	Y	More meat and fish	Better economy
CK18	Y	More meat and fish	Better econnomy
CK23	N		
CK24	N		Due to the childrens education costs, not much money
CK25	Y	More meat	Better economy
CK28	Y	More meat and fish and better quality of the food	Better economy and nutritional aspects
CK29	Y	More meat and fish	Better economy
CK30	Y	More meat and fish	Better economy and more knowledge about nutrition
CK36	N		
CK42	N		
CK45	Y	More fruit	Better economy
CK48	N		
CK49	Y	More variation and better quality of the food	Better economy
CK52	Y	More meat	Better economy
CK53	Y	More meat, fish and crab	Better economy
CK54	N		
CK55	N		

Source: The household questionnaires

Table A11. Food habit changes in the reference village, compared to five years back

Housecode	Food habit changes	Kind of changes	Reasons for the changes
CL	Y	More meat and fish	Better economy and more knowledge from TV about nutrition
CL01	Y	More variation	Better economy
CL02	Y	More meat and fish and more variation	Better economy
CL06	Y	More variation and better quality of the food	More knowledge about nutrition
CL07	Y	More meat and fish, more variation and better quality of the food	Better economy and more knowledge about nutrition
CL08	Y	More meat and fish	Better economy
CL09	Y	More variation	Better economy and more knowledge about nutrition
CL11	Y	More variation and better quality of the food	Better economy
CL12	Y		Better economy and more knowledge about nutrition
CL13	Y	More variation and more delicious	Better economy
CL15	Y	More meat and vegetables	Better economy
CL16	Y	More meat, fish and vegetables	Better economy
CL18	Y	More meat and fish	Better economy and due to nutritional aspect for the children
CL19	Y	More meat and fish, new dishes and better quality of the food	Better economy and more knowledge from school about nutrition
CL21	Y	More meat	Better economy and more knowledge about nutrition
CL22	Y	More variation	Better economy
CL23	Y	More meat and poultry	Better economy
CL24	Y	More fish and vegetables	Better economy
CL27	N		

Source: The household questionnaires