Iron deficiency in infancy: is an immigrant more at risk?

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Summary

QUESTIONS UNDER STUDY: Iron deficiency with or without anaemia is the most common deficiency in the world. Its prevalence is higher in developing countries and in low socioeconomic populations. We aimed at determining and comparing the prevalence of iron deficiency in an immigrant and non-immigrant population.

METHODS: Every child scheduled for a routine check-up at 12 months of age was allowed to participate in the study. Haemoglobin, ferritin, anthropometric data, familial and nutritional status were measured.

RESULTS: 586 infants were eligible and 463 were included in the study as they had assessment data at 12 months. Children were divided into two groups: immigrants' children and non-immigrants' children. The global prevalence of iron deficiency was 5.7% at 12 months. A significant difference for iron deficiency was noticed between the groups at 12 months (p = 0.01). Among risk factors, immigration (odds ratio 2.91; 95% CI 1.05–8.04) and unemployment (odds ratio 6.08; 95% CI 1.18–31.30) had the higher odds in the multivariable analysis.

CONCLUSION: The prevalence of iron deficiency in the immigrant population is higher than in non-immigrants. Immigration and the category of employment are risk factors for iron deficiency, as starting baby cereals before 9 months is a protective factor. Good socioeconomic conditions in Switzerland, the quality of food for pregnant women and young infants may be the explanation. A study up to five years of age is necessary before drawing general conclusions on infancy.

Key words: anaemia; iron-deficiency; infant; immigrants; risk factors of iron deficiency

Introduction

Iron deficiency with or without anaemia is the most common deficiency in the world, particularly in developing countries and in low socioeconomic populations [1–5]. The main cause of anaemia in infancy is low iron intake. Quick growth associated with inadequate intake puts children below 24 months of age at an increased risk of iron deficiency. In the long term, iron deficiency can cause neurocognitive problems, such as psychomotor development delay [6–12]. In the last few years, different risk factors have been reported in the literature: use of milk with poor iron content or excessive consumption of cow's milk, exclusive breastfeeding over 6 months, prematurity, low birth weight, chronic diseases, and low socioeconomic income [13–18]. Unemployment and poor living conditions are also recognised risk factors for iron deficiency.

Several studies also highlighted the link between acculturation and unhealthy diet. Working antisocial hours or increased hours worked outside of the home, unavailability or high prices of familiar food products, changes in income status are factors for unhealthy diet which can cause iron deficiency [19–21].

The prevalence of iron deficiency and iron-deficient anaemia is not known in Switzerland. Studies conducted in similar countries show that the prevalence of iron-deficient anaemia is between 2% and 5%, and the prevalence of iron deficiency is between 2% and 20%, with a higher prevalence in precarious populations [22–25].

Iron stores are sufficient for the first four to six months after birth. For this reason, deficiency usually does not develop before nine months of age. The Swiss Society of Paediatrics advises that the haemoglobin in every child between six and nine months of age be measured, in order to detect anaemia and treat it. These recommendations take into consideration neither the risk factors nor the impact of such a screening in terms of public health. Moreover, the measurement of haemoglobin does not detect iron deficiency without anaemia.

The aims of our study were to determine the prevalence of iron deficiency with or without anaemia in a part of French-speaking Switzerland that is known for a high percentage of the immigrant population, and to evaluate whether the children of immigrants are at higher risks than the local children.

Methods

Patient population

We conducted a prospective study in a population of infants aged 6 to 12 months and living in Lausanne and its suburbs. In this academic Swiss town with about 200,000 inhabitants and a multiethnic population, the Children's Hospital of Lausanne is a facility dedicated to children. A high pro-

portion of immigrants consult doctors there. At the Emergency Department, 60% of the consultations proceed from immigrants, with three quarters coming from European countries [26].

Three "family doctors" (paediatrician, general practitioner) and the Children's Hospital of Lausanne participated in the enrolment of patients. Between 1 November 2005 and 31 October 2007, every parent had been notified of a routine check-up for their six month old infants who were allowed to participate in the study. Exclusion criteria were parental refusal, haematological disease (haemoglobinopathy, enzymatic deficits, or erythrocyte membrane pathology), diseases that could cause anaemia, previous iron supplementation, and participation in other studies.

Children were divided into two groups: immigrants' and non-immigrants' children, according to the length of stay of their parents in Switzerland. Families were considered immigrants if they had been in the country ≤10 years at the time of the study. The "immigrants' group" was divided into two subgroups: those living in Switzerland for less than 5 years and those living there between 6 and 10 years. Unknown length of stay served as a criterion of exclusion from the analysis.

The duration of residence required for acquisition of citizenship varies enormously between European countries. Ranging from 3 (Belgium) to 12 years (Switzerland), the most common condition is 5 years of residence [27, 28]. The limit of 10 years to distinguish between immigrants and non-immigrants' condition has been artificially defined, based on the median time of residence required to apply for citizenship in Switzerland and in its neighbouring countries. Article 6 of the 1997 European Convention on Nationality (ECN) recommends also a maximum of 10 years of residence to be required.

Clinical and laboratory assessment

Paediatricians saw every child for a routine check-up at 12 (within 11 and 13) months of age. Weight, length, head circumference, duration of breastfeeding, time of introduction of formula, fruits and vegetables, cow's milk, and meat were assessed with a standardised questionnaire. A capillary blood sample was taken to measure the haemoglobin and ferritin levels. MCV, MCH and MCHC were also measured to exclude other causes of anaemia. We also assessed socioeconomic markers such as the professional category of each parent, their comprehension of the French language, and the origin of the parents.

Socioeconomic markers have been rated in two steps: firstly, we categorised job of mother and father according to the professional classification of Largo [29]. A new item was added for unemployment. Then, we summed employments of both parents to determine the socioeconomic level of the family. Housewives were categorised similarly to their husbands.

"Iron deficiency" and "iron-deficient anaemia" were defined according to Looker and Dallman [1]; ferritin below 10 µg/l for iron deficiency and haemoglobin below 110 g/l for anaemia. *Iron-deficient anaemia* was defined as iron deficiency with anaemia. In the case of iron deficiency or iron-deficient anaemia, children were given an oral treat-

ment of iron 3+ at a dose of 6 mg/kg/day for 3 months. A blood sample was taken at the end of the treatment.

The measurement of haemoglobin and ferritin was delayed if the child presented with 5 days of fever in the 10 days preceding study entry.

Statistical analysis

Data collected and blood results were entered in the Epidata database (Centers for Disease Control and Prevention, Atlanta, USA). Analyses were performed with Stata 12 (StataCorp LP, Texas, USA) and Epiinfo 3.4.3 (Centers for Disease Control and Prevention, Atlanta, USA). Unrecorded variables were coded as missing.

The aims of the statistical analyses were to determine the prevalence of iron deficiency stratified by groups and establish its risk factors. A p-value <0.05 was considered significant for any univariate analysis. Groups were compared based on their proportion of iron deficiency using non-parametric tests. Logistic regression models were fitted to calculate ORs for crude associations and associations adjusted for potential confounders.

This study was approved by the Ethics Committee of Lausanne. Parents received oral and written information and gave their informed consent.

Results

Patient population

A total of 586 infants were eligible and 463 were included in the study as they had assessment data at 12 months of age. Twenty-four children were secondarily excluded from the analysis: 13 for unknown length of stay, and 11 because of missing blood values (fig. 1).

The distribution among the two groups was 58.6% in the non-immigrants' group and 41.4% in the immigrants' group (20.7% in each subgroup). Our population is similar to our reference population with approximately 68% of permanent residents, 26% of annual permission to reside, and 6% of other permission to reside (table 1). The majority of immigrants came from European countries (West Europe: 70 (27.2 %) in the non-immigrants' group and 56 (30.8%) in the immigrants' group, East Europe: 20 (7.8 %) in the non-immigrants' group and 40 (21.98%) the immigrants' group). Switzerland represents 55.3% of the non-immigrants' group with 142 residents.

Mean age at the time of consultation was 12.15 months. There were 230 (52.4%) boys and 209 (47.6%) girls.

More than countries of origin, it is the socio-professional categories that change among the immigrant population. According to the kind of permission to reside and the duration of stay in Switzerland, the categories of employment change. Globally, the proportion of low income or unemployment is higher among people in Switzerland who have been living there for less than 10 years (table 1).

Clinical and laboratory results

Global prevalence of iron deficiency was 25 (5.7%) at 12 months. Median ferritin was 23.0 µg/l (4–166) at 12 months. Iron-deficient anaemia was diagnosed in two cases

(0.5 %) at 12 months. Median haemoglobin was 124.0 g/l (91–174) at 12 months.

There was a statistically significant difference in the prevalence of iron deficiency at 12 months with a prevalence of 3.1% iron deficiency in the non-immigrants' group versus 12.1% in the immigrants' group ≤5 years in Switzerland and 6.6% in the immigrants' group 6 to 10 years in Switzerland (p = 0.006). Iron-deficient anaemia has a low prevalence of 0.5%, with 2 cases. Mean haemoglobin did not differ significantly between groups (table 2).

With regard to food habits, the only statistically significant differences were the duration of breastfeeding and the time of introduction of fruits and vegetables. Breastfeeding lasted 4.02 months in the non-immigrants' group versus 4.79 months in the immigrants' group ≤5 years in Switzerland and 4.96 in the immigrants' group 6 to10 years in Switzerland (p = 0.035); fruits and vegetables were introduced at 5.35 months in the non-immigrants' group versus 5.07 months in immigrants' group ≤5 years in Switzerland and 5.08 in the immigrants' group 6–10 years in Switzerland (p = 0.001). Cow's milk was introduced at 10.51 versus

10.09 and 10.27 months, baby cereals at 6.74 versus 6.73 and 6.60 months, and meat at 6.61 versus 6.55 and 6.47 months, respectively (NS) (table 1).

Predictors of iron-deficiency

In the univariate analysis, the most significant predictors for iron-deficiency are the socio-professional background, especially if parents have a low income or are unemployed (p <0.005), duration of immigration, breastfeeding over 6 months and early cow's milk feeding. Baby cereals before 9 months seem to serve as a protective factor (table 3).

The multivariable analysis confirmed those predictors of iron deficiency, except for breastfeeding over 6 months of age and early cow's milk feeding. Immigration in the last 5 years and low income were the most significant predictors of iron deficiency, as the introduction of baby cereals before 9 months seems to serve as a protective factor (table 3).

Table 1: Patient demographics.

	General	Non-immigrants n (%)	Immigrants		p-value
			≤5 years in CH	6–10 years in CH	
No. total	439 (100%)	257 (58.6%)	91 (20.7%)	91 (20.7%)	
Permission to reside					
Swiss or naturalised citizen	147 (33.5%)	142 (55.3%)	1 (1.1%)	4 (4.4%)	N/A
Permanent permission to reside	151 (34.4%)	98 (38.1%)	11 (12.1%)	42 (46.1%)	
Annual permission to reside	112 (25.5%)	10 (3.9%)	65 (71.4%)	37 (40.7%)	
Other permission to reside	17 (3.9%)	0	10 (11.0%)	7 (7.7%)	
Unknown	12 (2.7%)	7 (2.7%)	4 (4.4%)	1 (1.1%)	
Gender					
Male	230 (52.4)	136 (52.9%)	45 (49.5%)	49 (53.8%)	0.810
Food habits					
Mean time of breastfeeding (sd)	4.370 (3.132)	4.019 (3.063)	4.793 (3.249)	4.959 (3.110)	0.035
Mean time of introduction of fruits/vegetables (sd) **	5.234 (0.830)	5.347 (0.840)	5.067 (0.802)	5.083 (0.783)	0.001
Mean time of introduction of cow's milk (sd)	10.352 (1.633)	10.510 (1.324)	10.094 (1.994)	10.273 (1.825)	0.712
Mean time of introduction of baby cereals (sd)	6.709 (0.977)	6.739 (0.997)	6.730 (1.075)	6.603 (0.804)	0.311
Mean time of introduction of meat (sd)	6.568 (0.883)	6.608 (0.869)	6.551 (0.957)	6.471 (0.847)	0.427
Category of income					
High and middle-class income n (%)	359 (81.8)	230 (89.5)	69 (75.8)	60 (65.9)	N/A
Low income	64 (14.6)	21 (8.2)	20 (22.0)	23 (25.3)	
Unemployment	14 (3.2)	4 (1.5)	2 (2.2)	8 (8.8)	
Missing values	2 (0.4 %)	2 (0.8%)	0	0	N/A

**: statistically significant
N/A: not applicable

Table 2: Laboratory characteristics of subjects.

	General n = 439	Non-immigrants n = 257	Immigrants		p-value
			≤5 years in CH n = 91	6–10 years in CH n = 91	
Median haemoglobin (range)	124.0 (91.0–174.0)	123 (91–174)	122 (105–147)	125 (98–146)	0.549
Median ferritin (range) **	23.0 (4.0–166.0)	23 (4–122)	19 (4–104)	24 (4–166)	0.036
Iron-deficiency n (%) **	25 (5.7%)	8 (3.1%)	11 (12.1%)	6 (6.6%)	0.006
Iron-deficient anaemia n (%)	2 (0.5%)	0 (0%)	1 (1.1%)	1 (1.1%)	0.242

**: Statistically significant
N/A: not applicable

Discussion

This study aimed at evaluating the prevalence of iron deficiency and iron-deficient anaemia in a part of French-speaking Switzerland known for a high percentage of the immigrant population, and also at assessing whether the children of immigrants were at higher risks than the local children.

The prevalence of iron deficiency in similar countries is between 2% and 20%. In our study, prevalence was generally in the mean for iron deficiency and low for iron-deficient anaemia.

At 12 months, we found a significant difference in the prevalence of iron deficiency between immigrants and non-immigrants. Among risk factors, we underline the prevalent role of immigration and employment as well as the protective effect of baby cereals, but not food diversification in itself.

As far as it is known, food is the main source of iron and, thus, the best way to avoid iron deficiency. It should be noted that in Switzerland, all baby cereals contain iron supplementation, which explains its protective role. Several studies mention iron supplementation in some kind of food, such as rice or cereals, as a means to treat and avoid iron deficiencies in low-income and poor families [12, 30–32].

One of the risk factors for iron deficiency is the immigrants' status. There are a number of definitions of a *migrant*, all focusing on one point or another. According to the UN convention on the rights of migrants, "The term **migrant** can be understood as *"any person who lives temporarily or permanently in a country where he or she was not born, and has acquired some significant social ties to this country."* However, this may be a too narrow definition when considering that, according to some states' policies, a person can be considered as a migrant even when s/he is born in the country" [33].

In our study, the first five years in a country seem to be crucial, after which the odds decline significantly (table 3). Migration and food have been largely studied, and the lack of some special kind of food as well as the contact with local people lead to changes in the diets. After a few years, people become accustomed to the host country, and new ingredients are included in the diet [21, 34, 35].

Breastfeeding interacts with every other variables in the multivariable analysis. Though the duration of breastfeeding varies between immigration's groups, our study cannot highlight any influence on iron deficiency.

Some studies report early cow's milk feeding as a factor of iron deficiency. We did not find any significant association, but the multivariable analysis shows that early cow's milk feeding interacts with the category of income as well as with the duration of immigration. The explanation could be of cultural habits or because of income difficulties, as infant formula is more expensive. Several studies also observe racial/ethnic disparities. We cannot exclude such an influence on our results, although we did not find any differences based on the origin of the parents. We did not investigate the link between ethnicity and socio-professional categories.

The strong correlation between the category of employment and iron deficiency enhances the link between socioeconomic conditions and iron deficiency, irrespective of the immigration status. Unemployment and low income multiply by six the risk of iron depletion and serve as our strongest predictor (table 3). Unfortunately, we only as-
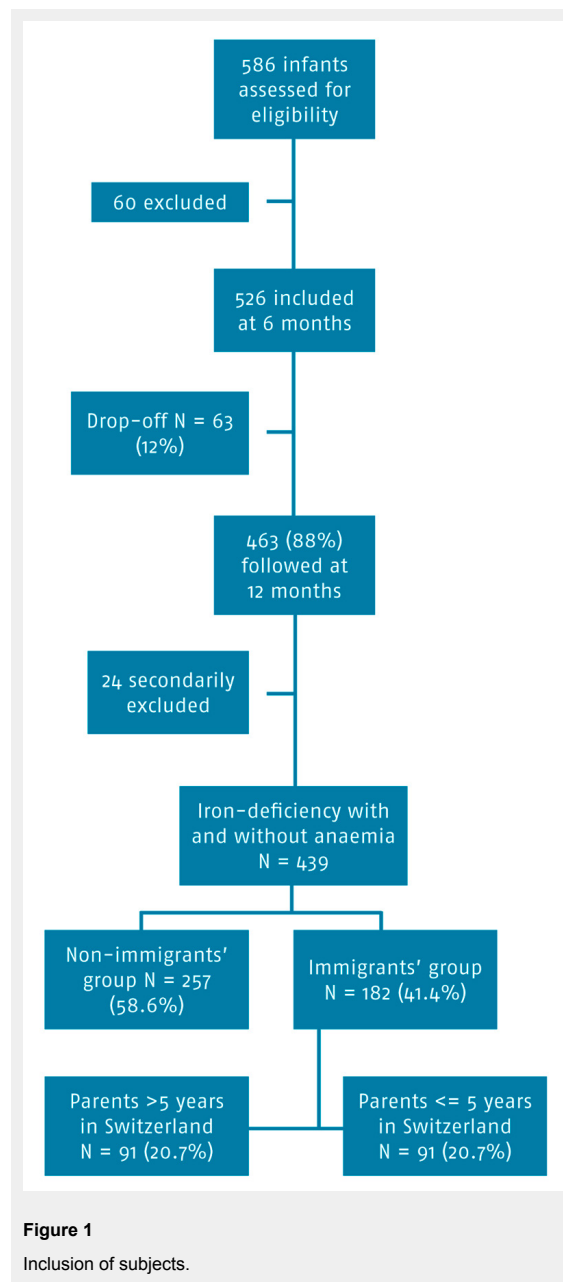
Parameters	Patients without iron-deficiency n = 414 (%)	Patients with iron-deficiency n = 25 (%)	Odds ratio	95% CI	p-value
Male	217 (94.3%)	13 (5.7%)	1.02	0.45–2.28	0.968
Small for date	23 (88.5%)	3 (11.5%)	2.27	0.63–8.15	0.208
Prematurity	17 (100%)	0 (0%)	Undefined	Undefined	N/A
Anaemia (Hb <110 g/l)	18 (90 %)	2 (10 %)	1.91	0.42–8.75	0.403
Median haemoglobin (range)**	124 (91–174)	119 (105–130)	0.922	0.88–0.97	0.001
Immigrants					
Non-immigrants	249 (96.9%)	8 (3.1%)	1		
0–5 years in Switzerland**	80 (87.9%)	11 (12.1%)	4.280	1.66–11.01	0.003
6–10 years in Switzerland	85 (93.4%)	6 (6.6%)	2.20	0.74–6.51	0.156
Nutrition					
Breastfeeding over 6 months**	11 (44 %)	14 (56 %)	1.70	0.76–3.84	0.199
Early cow's milk feeding (<9 months)**	34 (87.2%)	5 (12.8%)	2.79	0.99–7.91	0.053
Fruits before 6 months	281 (94.3%)	17 (5.7%)	1.01	0.42–2.39	0.99
Baby cereals after 9 months**	26 (81.3%)	6 (18.8%)	4.71	1.73–12.81	0.002
Meat before 6 months	26 (89.7%)	3 (10.3%)	2.04	0.57–7.25	0.273
Socioeconomic background					
Family <3 children	355 (93.9%)	23 (6.1%)	1.91	0.44–8.32	0.388
Single-parent family	16 (88.9%)	2 (11.1%)	2.14	0.46–9.85	0.331
Poor French comprehension of the mother	40 (90.9%)	4 (9.1%)	1.77	0.58–5.42	0.316
Socio-professional background					
High and middle-class income			1		
Low income**			5.35	2.2–13.0	0.000
Unemployment**			7.89	1.94–32.0	0.004

** Statistically significant
N/A: not applicable

sessed the time of introduction of each type of food. It would have been interesting to also assess its quantity, as socioeconomic conditions determine the quality and quantity of food ingested [36]. In contrast to what we expected, we did not find other known risk factors such as gender, prematurity, low birth weight, and prolonged breastfeeding. Good health, nutritional and socioeconomic conditions of our country can explain those differences. However, recruiting our population through three paediatricians and a paediatric hospital may have induced a selection bias; all patients included, as most people in Switzerland, had an optimal access to health care and a regular medical follow-up.

Serum ferritin is the most common and inexpensive tool for the detection of iron deficiency. It is, however, influenced by inflammation or infection [37]. Though we delayed the blood tests in every child presenting fever, we could not exclude some falsely elevated ferritin in our sample. Usually, iron-deficient anaemia is discovered at two or three years of age. Our study permitted the detection and treatment of many iron deficiencies at 12 months.

We conclude that in our studied population, the prevalence of iron deficiency was lower than that reported in the literature for a similar population. Good socioeconomic conditions in Switzerland, the quality of food for pregnant women and young infants can explain this phenomenon. Immigrants are more at risk than non-immigrants, especially after six months of age. Low income and unemployment in both groups seem to be the best predictors of iron deficiency. A study up to five years of age is needed before drawing general conclusions on infancy.

Key-points

Prevalence of iron deficiency is lower than that reported in the literature for a similar population.

Low income and immigration seem to be the best predictors of iron deficiency.

Starting baby cereals before nine months is a protective factor.

Figure 1

Inclusion of subjects.

Table 4: Predictors of iron-deficiency with or without anaemia at 12 months (multivariable analysis).

Risk factors	Adjusted odds ratio	95% CI	p-value
Immigration			
Non-immigrants	1		
Immigration at 0–5 years in CH**	2.91	1.05–8.04	0.0399
Immigration at 6–10 years in CH	1.12	0.32–3.93	0.8556
Nutrition			
Early cow's milk feeding	3.0481	0.96–9.68	0.0587
Baby cereals after 9 months**	6.8872	2.18–21.77	0.0010
Breastfeeding over 6 months	1.9606	0.80–4.82	0.1427
Socio-professional background			
High and middle-class income	1		
Low income**	5.9308	2.18–16.11	0.0005
Unemployment**	6.0861	1.18–31.30	0.0307
**Statistically significant			

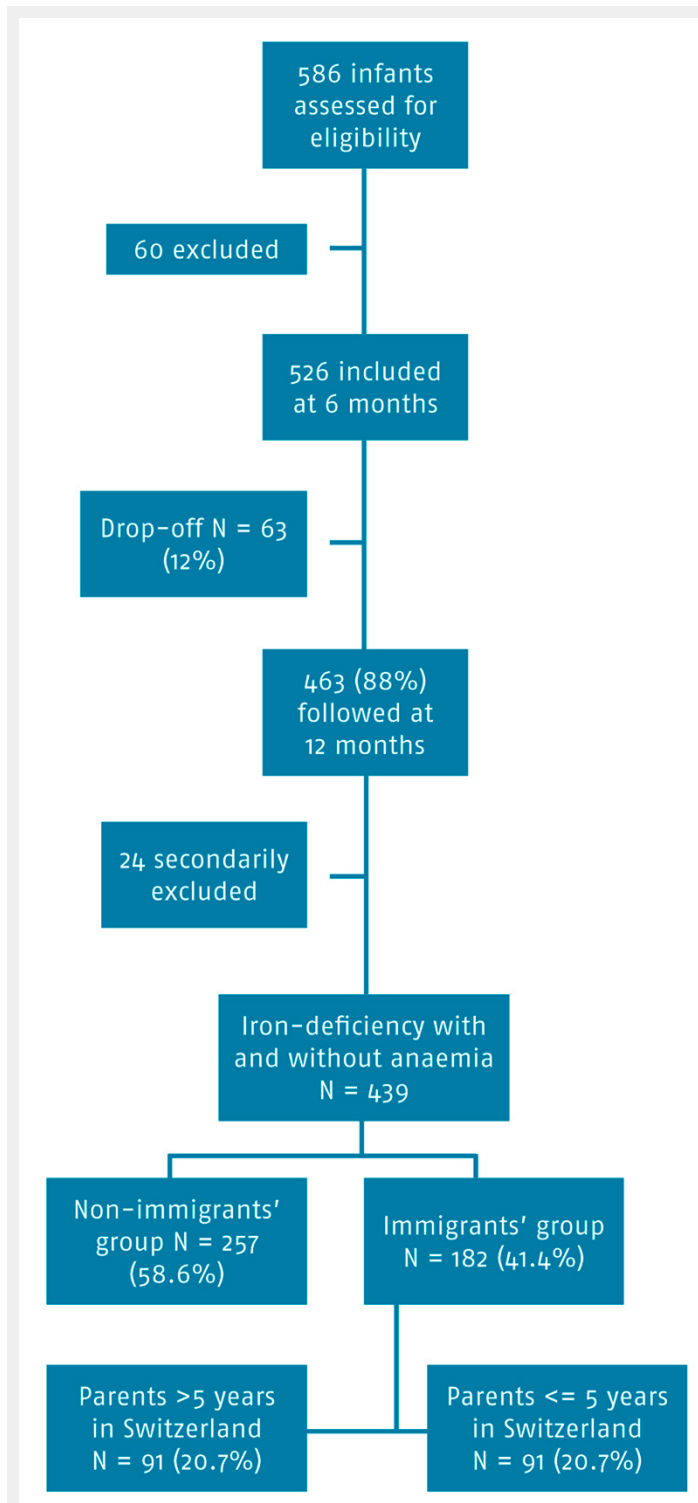congress of the Swiss Society of Paediatrics in Montreux on 1 September 2011.

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Figures (large format)

Figure 1

Inclusion of subjects.