Potential Contribution of Iron Deficiency and Multiple Factors to Anemia among 6- to 72-Month-Old Children in the Kokang Area of Myanmar

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Abstract. The prevalence of anemia among children in Myanmar has been reported to be among the highest in the world. This study was conducted to determine 1) the prevalence of anemia in preschool children and 2) risk factors associated with anemia. A total of 138 children aged from 6 to 72 months were recruited through cluster sampling from six villages in Kokang. Hemoglobin (Hb) concentration, blood trace elements, and anthropometric indicators were measured. Feces samples were collected to examine for the presence of ascarid eggs. The overall prevalence of anemia in children was 61.6%, including 10.9% with severe anemia. Meanwhile, high prevalence of stunting (40.0%), underweight (22.4%), wasting (6.3%), and small head circumference (6.7%) was found. Children with anemia were more prone to stunting. Children with severe anemia and moderate anemia had significantly lower blood iron and zinc levels than children without anemia ($P < 0.001$ and $P = 0.007$). The prevalence of ascarid infection was 64.9%; however, it was not associated with anemia. Drinking spring water was positively associated with anemia (odds ratio [OR] = 6.368). This study demonstrated that anemia is an important public health problem among children from the Kokang area. Iron deficiency and drinking spring water may be the important causes of anemia among children.

INTRODUCTION

More than 1.6 billion people worldwide are anemic and the prevalence is highest in southeast Asia.^{1,2} In 2010, south Asia accounted for 37.5% of the entire global anemia years of life lived with disability.³ The preschool children in this region were the most vulnerable group.⁴ Myanmar is the largest country in southeast Asia geographically, with over 70% of its population residing in rural areas and over 60% of the population being mothers and children.⁵ The prevalence of anemia in some regions of Myanmar is reported to be unacceptably high, at around 70% in children.^{6,7} Previous studies reported that anemia in children may lead to many adverse consequences, especially, potentially irreversible cognitive deficits associated with impairment to central nervous system structure, metabolic development, and increased mortality and morbidity.^{8,9}

In this study, children from six villages in the Kokang area in Shan State of Myanmar were investigated. The prevalence of anemia in this region is still unknown. According to the report from the Myanmar government in 2012, the poverty incidence and underweight rate in the Shan region were the highest among the country,¹⁰ while the postnatal care coverage rate (60–70%) was the lowest.¹⁰ Although humanitarian assistance for children's immunization and malaria control has greatly improved the health of local children, children in these areas are still facing the problems of food shortages and poor living conditions.^{6,11} Because of the reported association between anemia and dietary intake and nutritional status, the prevalence of anemia in this region is expected to be high.

Humanitarian organizations are considering a nutritional supplement intervention program to improve the children's

health in this area. According to our study, in 2011, in addition to nutrition, multiple factors were associated with child anemia in Myanmar, such as low family income, infectious diseases, and drinking unboiled spring water.⁶ This study intends to further investigate the causes of anemia in this region by measuring hemoglobin (Hb) and blood trace elements. In addition, we also assess helminth infection in children. Evaluation before implementation is necessary for humanitarian relief planners to select appropriate interventions and to budget wisely for an overall relief effort.¹²

METHODS

Study participants. The study participants were enrolled in the Kokang area of Shan State in Myanmar from July to August 2014. A total of six villages were selected by convenient sampling. Cluster sampling was used for screening all the children who were aged between 6 and 72 months in each village. Disabled children and children who lived in the local area for less than 8 months per year were excluded from this study. A total of 141 children were recruited and 138 children qualified and volunteered to participate in this survey (including 17 pairs of siblings). Blood samples (40 μ L for each child) were collected from 94 children to analyze the blood trace elements. The other 44 children failed to provide blood samples mainly because of prolonged crying. Feces samples were also collected from 41 children who defecated on the day of investigation and these were used to test for parasitic infection.

Data collection and measurement. The fieldwork was carried out by local health professionals and staff from Health Poverty Action (HPA, a British nongovernmental organization founded in 1984 that works to strengthen poor and marginalized people in their struggle for health) with the support of local health officers. A validated interviewer-administered questionnaire was used to collect data on sociodemographic characteristics and self-reported children's health-related status for information on diseases and symptoms that had occurred

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in the past 3 months. The children's primary caregivers (typically mothers) were interviewed. The food intake frequencies were also investigated for three food categories including meat, egg, and dairy products, which are considered to be the dietary source of iron or protein. The frequencies were described as 1) never or less than once a week, 2) 1–6 times/week, and 3) daily. The preliminary questionnaire testing was completed in Kachin State in Myanmar in 2011.⁶ Training of examiners and interviewers and a pilot study were performed before data collection.

An Electronic Infant/Child Shorrboard (Infant/Child Shorrboard RSP-2060B; Huachao Medical Instruments Co. Ltd., Zhejiang, China) was used to measure both infant/child weight with infants' clothing, shoes, and diapers removed and recumbent infant/child length (if the child was younger than 24 months old). The weight and height of children who were older than 24 months were measured using a portable scale (Portable scale RGZ-50; Suhong Medical Instruments Co. Ltd., Jiangsu, China). Head circumference (HC) was measured with a tape. Mid-upper arm circumference (MUAC) was measured around the left arm using single-slotted insertion tapes. The weight-for-age ratio z -score (WAZ), height-for-age ratio z score (HAZ), weight-for-height ratio z score (WHZ), and HC z score of children who were aged < 60 months and $\geq$ 60 months were calculated using the World Health Organization (WHO) Anthro software and WHO AnthroPlus software, respectively (Department of Nutrition, World Health Organization, Geneva, Switzerland). According to the WHO's Child Growth Standards 2006,¹³ WAZ < -2, HAZ < -2, and WHZ < -2 are defined as underweight, stunting, and wasting, respectively. An HC z score < -2 is defined as small HC. An MUAC z score (MUAC Z) < -2 is considered as wasting. Children who had edema ($N = 2$) and unknown cause of an obvious big belly ($N = 3$) were recorded and their data were not used to calculate the WAZ and WHZ.

Blood samples were obtained from finger pricks from children. Hb levels were measured during the fieldwork using HemoCue (HemoCue Hb 201 + analyzer; HemoCue AB, Angelholm, Sweden). The presence and severity of anemia were diagnosed using age-based Hb criteria designated by the WHO, which defines moderate anemia as Hb < 110 g/L for children aged 6–59.9 months, Hb < 115 g/L for children aged 60–71.9 months, and severe anemia as Hb < 80 g/L for children between 6 and 72 months.¹⁴ A total of 40 μ L of whole blood was collected to test trace elements (iron, zinc, magnesium, copper, and calcium) using the atomic absorption method. Atomic absorption analysis kits (Bohui Innovation Photoelectric Technology Co. Ltd., Beijing, China) and a V5 5100s atomic absorption spectrometer (Bohui Innovation Photoelectric Technology Co. Ltd.) were used for analysis.

Feces were collected and examined during the fieldwork by physiological saline direct smear method for the presence of eggs of *Ascaris lumbricoides*.

Ethics. The study was conducted in compliance with the Declaration of Helsinki and approved by the Kokang government. Written consent was obtained from the primary caregivers of all participants by interviewers before data collection.

Statistical analyses. Service Solutions version 20.0 (SPSS Inc., Chicago, IL) was used to carry out the analysis. Descriptive statistics were completed for all the variables and presented as mean $\pm$ standard deviation (SD), median (25th, 75th), or frequencies. Differences in proportions were tested

with the χ^2 test. Analysis of variance and nonparametric test were used to analyze the differences in character among children who had anemia and those who did not. Logistic regression (with the backward Wald method) was used to obtain ORs and 95% confidence intervals (95% CI) to estimate the associations between anemia and the predictors. In the multivariate analysis, only demographic factors and environmental factors that were found to be associated with anemia in single analysis were entered into the regression model. Nonsignificant variables were removed from the final model. A P value < 0.05 was considered statistically significantly different.

RESULTS

Demographic characteristics of participants. A total of 138 children qualified and participated in this study; 55.1% were male and 44.9% were female. The main ethnic group was Kokang (89.4%), followed by De'ang (10.6%). The mean age of the children was 31.8 ± 19.0 months, with 46.4% children aged from 6 to 24 months, 34.4% aged from 24.1 to 48 months, and 19.6% aged from 48.1 to 72 months.

Prevalence of anemia. The overall anemia prevalence was 61.6%, with 10.9% reported as being severely anemic. The anemia prevalence in the 6–24, 24.1–48, and 48.1–72 month age groups was 77.0%, 49.1%, and 50.0%, respectively. Children younger than 24 months were more susceptible to anemia than older children ($\chi^2 = 11.045$, $P = 0.004$). By gender, the anemia prevalence was 63.2% for boys and 59.7% for girls. There was no gender difference for anemia ($\chi^2 = 0.175$, $P = 0.676$). Children of De'ang nationality were more susceptible to anemia (86.7%) than those of Kokang nationality (58.5%) ($\chi^2 = 4.472$, $P = 0.034$).

Growth and development indicators of participants. In this survey, 40.0% children were reported as stunting (HAZ < -2), 22.4% were underweight (WAZ < -2), and 6.3% were wasting (WHZ < -2). A proportion of 6.7% of children had a small HC (< -2). The results of the MUAC measurement showed that 5.2% children had an MUAC Z below -2. In the fieldwork, two children were found to have edema, while three children were found to have an obvious big belly. Compared with nonanemic children, children with moderate anemia and severe anemia had a significantly lower HAZ score (see Table 1).

Blood trace elements of children with or without anemia. Blood trace elements were tested in 94 children. Children with moderate anemia and severe anemia had significantly lower zinc and iron levels in their blood than children without anemia (see Table 2).

Health and health-related status of children with or without anemia. On the basis of the medical records and self-report, four children had had measles in the last 3 months and no children had reported malaria or acquired immunodeficiency syndrome recently. Caregivers reported that 49 (34.7%) and 58 (41.1%) children had experienced diarrhea and fever for unknown reasons in the last 3 months, respectively. Self-reported incidence of diarrhea and fever was not associated with anemia in this study ($\chi^2 = 0.801$, $P = 0.371$, and $\chi^2 = 0.010$, $P = 0.922$, respectively).

In this survey, the overall *Ascaris* infection rate was 64.9%. The *Ascaris* infection rate in children with anemia was 62.5%, whereas it was 65.0% in children without anemia ($\chi^2 = 0.024$, $P = 0.877$).

TABLE 1

Comparison of WHZ, HAZ, WAZ, HC Z, and MUAC Z among children without anemia, with moderate anemia, and with severe anemia

z Scores (mean $\pm$ SD)	Children without anemia	Children with moderate anemia	Children with severe anemia	F/ χ^2	P
WHZ‡	N = 46 -0.323 $\pm$ 1.438	N = 54 -0.106 $\pm$ 1.409	N = 17 0.118 $\pm$ 1.461	0.659	0.520
HAZ*	N = 49 -1.032 $\pm$ 2.281	N = 58 -1.819 $\pm$ 1.418	N = 17 -2.495 $\pm$ 1.218	5.018	0.008
WAZ†‡	N = 51 -0.880 (-0.193, -0.260)	N = 56 -0.815 (-0.1605, -0.700)	N = 17 -1.540 (-2.180, -0.750)	1.362	0.506
HC Z	N = 52 -0.347 $\pm$ 1.686	N = 62 -0.573 $\pm$ 1.340	N = 17 -0.476 $\pm$ 1.643	0.746	0.476
MUAC Z	N = 52 -0.168 $\pm$ 1.008	N = 62 0.015 $\pm$ 1.134	N = 17 0.187 $\pm$ 1.633	0.705	0.496

HAZ = height-for-age z score; HC z = head circumference z score; MUAC Z = mid-upper arm circumference z score; WAZ = weight-for-age z score; WHZ = weight-for-height z score.

*The Fisher's Least Significant Difference (LSD) test post hoc test was used for multiple comparison; children with moderate anemia and severe anemia had a significantly lower HAZ than children without anemia ($P = 0.006$ and $P = 0.024$, respectively).

†Kolmogorov-Smirnov test was used to test for normality before analysis; WAZ was described as median (25th, 75th) and analyzed with nonparametric test.

‡Children who had edema ($N = 2$) and unknown cause of an obvious big belly ($N = 3$) were not used to calculate the WAZ and WHZ.

Sociodemographic characteristics of children with or without anemia. In the investigated region, 52.0% of children's families had an annual per capita income lower than US\$160. Only 38.8% of children's families had a self-built toilet. Low education levels were found among parents, with 74.4% mothers and 66.1% fathers being illiterate. Well water was the main source of water (42.5%), followed by pool water (34.3%) and spring water (23.2%). Children who drank spring water had a significantly higher prevalence of anemia than children who drank well and pool water. Other factors were not associated with anemia in children (see Table 3).

Food intake of children with or without anemia. According to HPA records, 51 children (38.3%) had accepted nutrition packages (most children aged 6–36 months; the nutrition package contains macronutrients and micronutrients) and six children (4.8%) had accepted relief food (rice) in the last 6 months. In the 6–24 month group, 40.7%, 61.0%, and 40.7% children reported intake of meat, eggs, and dairy products less than once a week, respectively. In the 24.1–72 month group, 11.4%, 47.1%, and 54.3% children had meat, eggs, and dairy products less than once a week, respectively. Food intake frequencies were not associated with anemia (P all > 0.05).

Logistic regression analysis. According to the single-factor analysis, ethnicity, age, and source of water were entered into the logistic regression model. Finally, drinking spring water was found to be associated with anemia ($b = 1.851$, Wald = 10.516, OR = 6.368, 95% CI = 2.080, 19.495, $P = 0.001$). Children younger than 24 months were more likely to drink spring water ($\chi^2 = 54.201$, $P < 0.001$).

DISCUSSION

Prevalence of anemia. Myanmar is one of the least developed countries in the world. It has a long history of conflicts since the Second World War. The regional conflict in Kokang lasted until 2010 and broke out again in 2015. The political

instability was a threat to the health status of children. Anemia is still widespread in Myanmar, along with a high risk of child mortality.¹⁴

In this survey, the overall anemia prevalence was 61.6%, with 10.9% being severely anemic, which is lower than the reported prevalence of anemia among children (72.6%) in Kachin and Shan (east) states in 2011.⁶ However, this number is higher than the mean prevalence in children from southeast Asia (49%)¹⁵ and much higher than the mean prevalence (13.6%) in children from Yunnan province, China (Yunnan geographically borders Kokang)¹⁶ and other developing countries, such as Nepal (37.9%)¹⁷ and Kenya (28.8%).¹⁸ Although age was finally excluded from the regression model because it was highly correlated with source of water, children aged 6–24 months seemed to be the group most vulnerable to anemia according to previous studies.^{6,19} The proportion of children with severe anemia was 10.9%, as high as that reported in a study of refugee children on the Thai-Myanmar border (10.4%).⁷

Growth and development of children. According to our results, 40.4%, 22.4%, and 6.3% children were stunting, underweight, and wasting, respectively. These data were similar to those in the WHO report on the health status of Myanmar children.²⁰ It is also worth noting that we found two children with edema. This indicated that kwashiorkor might exist in this region. Also, a high prevalence of small HC was found in this survey, which implied delayed brain development. Previous studies demonstrated that anemia could lead to cognitive impairment, lack of physical capacity, and even life-threatening consequences.⁹ In this study, we found that stunting was shown to be associated with anemia, which was consistent with our previous study.⁶ However, the causality between malnutrition and anemia could not be seen in this study.

Risk factors associated with anemia. In developing countries, most cases of anemia are partly or exclusively caused

TABLE 2

Blood micronutrients in children with moderate anemia, severe anemia, and without anemia

Micronutrients	Children without anemia, N = 46	Children with moderate anemia, N = 42	Children with severe anemia, N = 4	F/ χ^2	P
Iron (mmol/L)	7.90 $\pm$ 0.73	7.28 $\pm$ 0.74	6.63 $\pm$ 0.77	9.081	< 0.001
Zinc (μ mol/L)*	80.66 (72.18, 95.50)	71.16 (64.43, 92.53)	58.72 (49.62, 64.86)	10.045	0.007
Magnesium (mmol/L)	1.63 $\pm$ 0.19	1.58 $\pm$ 0.26	1.53 $\pm$ 0.18	0.791	0.456
Copper (μ mol/L)	19.01 $\pm$ 3.12	19.08 $\pm$ 5.45	20.28 $\pm$ 3.98	0.154	0.858
Calcium (mmol/L)*	1.87 (1.77, 2.00)	1.86 (1.73, 2.04)	1.83 (1.70, 1.99)	0.753	0.686

*Kolmogorov-Smirnov test was used to test for normality before analysis; zinc and calcium were described as median (25th, 75th) and analyzed with nonparametric test.

TABLE 3
Comparison of sociodemographic characteristics between children with and without anemia (N, %)

	Children without anemia	Children with anemia	χ^2	P
Family annual per capita income (U.S. dollars)			0.122	0.941
< 160	24 (50.0)	42 (52.5)		
160–480	7 (14.6)	11 (13.8)		
> 480	17 (35.4)	27 (33.8)		
Toilet			1.916	0.166
No toilet	35 (68.6)	47 (56.6)		
Self-built toilet	16 (31.4)	36 (43.4)		
Source of water			11.500	0.003
Pool water	23 (45.1)	23 (27.7)		
Well water	24 (47.1)	33 (39.8)		
Spring water	4 (7.8)	27 (32.5)		
Education experience (mothers)			2.968	0.085
Illiterate	41 (85.4)	60 (72.3)		
Primary school or above	7 (14.6)	23 (27.7)		
Education experience (fathers)			3.412	0.065
Illiterate	27 (56.3)	55 (72.4)		
Primary school or above	21 (43.8)	21 (27.6)		

by micronutrient deficiency along with other risk factors.^{21,22} Our previous study in 2011 reported an extremely low intake of iron-rich food by children aged 6–36 months.⁶ Meanwhile, a high prevalence of thalassemia was also reported in Myanmar.²² These results led to a research question on whether the high prevalence of anemia in Myanmar was caused by micronutrient deficiencies or not. In this survey, a large proportion of children did not consume eggs or meat on a daily basis, which might result in an insufficient intake of dietary iron.²² In addition, the children who had moderate anemia and severe anemia had significantly lower iron and zinc levels in their blood samples than those without anemia. This finding first confirmed that micronutrient deficiency was an important cause of anemia in children from Myanmar. In addition, deficiencies of zinc and iron might also impair children's cognitive development, resulting in stunting and even a threat to life.^{22,23}

Both this survey and our study performed in 2011 found that drinking unboiled spring water was associated with anemia,⁶ which might be related to parasitic infection.²⁴ However, due to the limited sample size, the *Ascaris* infection was not associated with anemia. This survey also reflected an alarming rate of *Ascaris* infection among children from Kokang. Parasitic infection could be the cause of intestinal bleeding-induced anemia, especially when it is known that the main water source was spring or river water.²⁵ A study in South Africa even reported that infectious diseases, including parasitic infection and iron deficiency, were the major cause of anemia.²⁶ It is also worth noting that most of the investigated children were living in poor environments (low family income, low level of education of both mothers and fathers, and no hygienic toilet), which might give rise to malnutrition and anemia and threaten the health of children.

Limitations. Because of the cross-sectional design, the causality between exposure factors and anemia was not observed. In addition, there may have been recall bias on the part of the caregivers during the interviews, which may have affected the reliability of their reports. The sampling approach used in this study is an inevitable compromise bearing in mind the several constraints due to the local social environment. The first limitation of our study comes from the fact that stratified random sampling cannot be applied since some villages were not accessible. We estimated that the prevalence of anemia

among children in those villages might be higher. Another limitation lies in the samples, in that 17 pairs of children were from one family and shared the same socioeconomic environment; therefore, the association between anemia and some risk factors may have been overestimated. However, the same results were found when we removed the siblings (results not shown in this study). The results still reflect the general level of anemia in this region and the poor nutritional status of the children.

Unfortunately, in this survey we did not measure indicators such as serum ferritin, transferrin saturation, and erythrocyte protoporphyrin due to the restricted working conditions. The results of this study showed that children of De'ang nationality were more susceptible to anemia than children of Kokang nationality in single-factor analysis. The possibility of a genetic cause of anemia still cannot be excluded. However, this study focused on exploring the controllable factors associated with anemia and found that micronutrient deficiency was one of the most important causes of anemia in the Kokang area.

CONCLUSION

Anemia can usually be prevented at a low cost, and the benefit/cost ratio of implementing preventive programs is recognized as one of the highest in the field of public health.⁹ This study pointed out that children in rural areas of Kokang had a high prevalence of anemia and poor nutritional status. Micronutrient deficiency might be one of the most important causes of anemia among multiple contributing factors. A combination of interventions, including nutrition promotion, infectious disease control, and improving living conditions, may be the ideal way to achieve a reduced level of anemia among children.

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REFERENCES

- McLean E, Cogswell M, Egli I, Wojdyla D, de Benoist B, 2009. Worldwide prevalence of anaemia, WHO Vitamin and Mineral Nutrition Information System, 1993–2005. *Public Health Nutr* 12: 444–454.
- Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, Mathers C, Rivera J, 2008. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet* 371: 243–260.
- Kassebaum NJ, Jasrasaria R, Naghavi M, Wulf SK, Johns N, Lozano R, Regan M, Weatherall D, Chou DP, Eisele TP, Flaxman SR, Pullan RL, Brooker SJ, Murray CJ, 2014. A systematic analysis of global anemia burden from 1990 to 2010. *Blood* 123: 615–624.
- Pasricha SR, Hayes E, Kalumba K, Biggs BA, 2013. Effect of daily iron supplementation on health in children aged 4–23 months: a systematic review and meta-analysis of randomised controlled trials. *Lancet Glob Health* 1: e77–e86.
- Htay TT, 2007. Making pregnancy safer in Myanmar: introducing misoprostol to prevent post-partum haemorrhage as part of active management of the third stage of labour. *Reprod Health Matters* 15: 214–215.
- Zhao A, Zhang Y, Peng Y, Li J, Yang T, Liu Z, Lv Y, Wang P, 2012. Prevalence of anemia and its risk factors among children 6–36 months old in Burma. *Am J Trop Med Hyg* 87: 306–311.
- Kemmer TM, Bovill ME, Kongsomboon W, Hansch SJ, Geisler KL, Cheney C, Shell-Duncan BK, Drewnowski A, 2003. Iron deficiency is unacceptably high in refugee children from Burma. *J Nutr* 133: 4143–4149.
- Beard JL, 2008. Why iron deficiency is important in infant development. *J Nutr* 138: 2534–2536.
- Kotecha PV, 2011. Nutritional anemia in young children with a focus on Asia and India. *Indian J Community Med* 36: 8–16.
- Ministry of Health, the Republic of the Union of Myanmar, 2014. *Public Health Statistics 2012*. Available at: <http://www.moh.gov.mm/file/Myanmar%20Health%20Statistics%202010.pdf>. Accessed November 5, 2014.
- Zhao A, Zhang Y, Li B, Wang P, Li J, Xue Y, Gao H, 2014. Prevalence of anemia and its risk factors among lactating mothers in Myanmar. *Am J Trop Med Hyg* 90: 963–967.
- Hansch S, 1995. *Health: How Many People Die of Starvation in Humanitarian Emergencies?* Working Paper of the Refugee Policy Group, Center for Policy Analysis and Research for Refugee Issues, Washington, DC.
- WHO Multicentre Growth Reference Study Group, 2006. *WHO Child Growth Standards: Length/Height-for-Age, Weight-for-Age, Weight-for-Length, Weight-for-Height and Body Mass Index-for-Age: Methods and Development*. Geneva, Switzerland: World Health Organization.
- UNICEF/UNU/WHO/MI Technical Workshop, 1998. *Preventing Iron Deficiency in Women and Children: Technical Consensus on Key Issues*. Available at: http://www.inffoundation.org/pdf/prevent_iron_def.pdf. Accessed November 8, 2014.
- DeMaeyer E, Adiels-Tegman M, 1985. The prevalence of anemia in the world. *World Health Stat Q* 38: 302–316.
- Yao LQ, Zou TB, Liu JT, Quan X, Chen Q, Yang FB, Hu LS, Zhao ZM, Wang XT, 2013. A survey on anemia among children under 7 years of age from 15 minority ethnic groups in Yunnan. *Zhonghua Er Ke Za Zhi* 9: 34–41.
- Khatiwada S, Gelal B, Gautam S, Tamang MK, Shakya PR, Lamsal M, Baral N, 2015. Anemia among school children in eastern Nepal. *J Trop Pediatr* 61: 231–233.
- Ngesa O, Mwambi H, 2014. Prevalence and risk factors of anaemia among children aged between 6 months and 14 years in Kenya. *PLoS One* 9: e113756.
- Provan D, 1999. Mechanisms and management of iron deficiency anaemia. *Br J Haematol* 105 (Suppl 1): 19–26.
- WHO, 2014. *Country Profile: Myanmar*. Available at: <http://www.who.int/countries/mmr/en/>. Accessed November 8, 2014.
- Choi JW, Kim SK, 2005. Relationships of lead, copper, zinc, and cadmium levels versus hematopoiesis and iron parameters in healthy adolescents. *Ann Clin Lab Sci* 35: 428–434.
- Usha R, Semba RD, 2001. Iron deficiency and anemia. Semba RD, Bloem MW. *Nutrition and Health in Developing Countries*. Totowa, NJ: Humana Press Inc., 479–505.
- Stammers AL, Lowe NM, Medina MW, Patel S, Dykes F, Perez-Rodrigo C, Serra-Majam L, Nissensohn M, Moran VH, 2014. The relationship between zinc intake and growth in children aged 1–8 years: a systematic review and meta-analysis. *Eur J Clin Nutr* 69: 147–153. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/?term=The+relationship+between+zinc+intake+and+growth+in+children+aged+1-8+years%3A+a+systematic+review+and+meta-analysis>. Accessed January 2, 2015.
- Cifuentes E, 1998. The epidemiology of enteric infections in agricultural communities exposed to wastewater irrigation: irrigation: perspectives for risk control. *Int J Environ Health Res* 8: 203–213.
- Latham MC, 1997. *Human Nutrition in the Developing World. Food and Agriculture*. Available at: <http://www.fao.org/DOCREP/W0073e/w0073e00.htm>. Accessed November 12, 2014.
- Mamabolo RL, Alberts M, 2014. Prevalence of anaemia and its associated factors in African children at one and three years residing in the Capricorn District of Limpopo Province, South Africa. *Curationis* 37: 1–9.