Prevalence of malnutrition among HIV-infected children in Central and West-African HIV-care programmes supported by the Growing Up Programme in 2011: a cross-sectional study

Julie Jesson1,2*, David Masson3, Arsène Adonon4, Caroline Tran3, Capitoline Habarugira5, Réjane Zio3, Léoncie Nicimpaye6, Sophie Desmonde1,2, Goreth Serurakuba7, Rosine Kwayep8, Edith Sare9, Tiefing Konate10, Abdoulaye Nimaga11, Philemon Saina12, Akossiwa Kpade13, Andrée Bassuka14, Gustave Gougouyor15, Valériane Leroy1,2 and for the Growing Up Working Group

Abstract

**Background:** The burden of malnutrition among HIV-infected children is not well described in sub-Saharan Africa, even though it is an important problem to take into account to guarantee appropriate healthcare for these children. We assessed the prevalence of malnutrition and its associated factors among HIV-infected children in HIV care programmes in Central and West-Africa.

**Methods:** A cross-sectional study was conducted from September to December 2011 among the active files of HIV-infected children aged 2–19 years old, enrolled in HIV-care programmes supported by the Sidaction Growing Up Programme in Benin, Burundi, Cameroon, Côte d’Ivoire, Mali, Chad and Togo. Socio-demographics characteristics, anthropometric, clinical data, and nutritional support were collected. Anthropometric indicators, expressed in Z-scores, were used to define malnutrition: Height-for-age (HAZ), Weight-for-Height (WHZ) for children < 5 years and BMI-for-age (BAZ) for children ≥5 years. Three types of malnutrition were defined: acute malnutrition (WHZ/BAZ < -2 SD and HAZ ≥ -2 SD), chronic malnutrition (HAZ < -2 SD and WHZ/BAZ ≥ -2 SD) and mixed malnutrition (WHZ/BAZ < -2 SD and HAZ < -2 SD). A multinomial logistic regression model explored associated factors with each type of malnutrition.

**Results:** Overall, 1350 HIV-infected children were included; their median age was 10 years (interquartile range [IQR]: 7–13 years), 49% were girls. 80% were on antiretroviral treatment (ART), for a median time of 36 months. The prevalence of malnutrition was 42% (95% confidence interval [95% CI]: 40-44%) with acute, chronic and mixed malnutrition at 9% (95% CI: 6–12%), 26% (95% CI: 23–28%), and 7% (95% CI: 5–10%), respectively. Among those malnourished, more than half of children didn’t receive any nutritional support at the time of the survey. Acute malnutrition was associated with male gender, severe immunodeficiency, and the absence of ART; chronic malnutrition with male gender and age (<5 years); and mixed malnutrition with male gender, age (<5 years), severe immunodeficiency and recent ART initiation (<6 months). Orphanhood and Cotrimoxazole prophylaxis were not associated with any type of malnutrition.

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Conclusions: The prevalence of malnutrition in HIV-infected children even on ART remains high in HIV care programmes. Anthropometric measurements and appropriate nutritional care of malnourished HIV-infected children remain insufficient and a priority to improve health care of HIV-infected children in Africa.

Keywords: HIV, Children, Malnutrition, Nutritional support, Africa

Background

In 2012, 3.3 million children were living with Human Immunodeficiency Virus (HIV) worldwide, with more than 90 % in sub-Saharan Africa [1]. Regardless of HIV, sub-Saharan Africa is also the region of the world the most seriously affected by malnutrition, 21 % of children under 5 years are underweight, 39 % are stunted, and 9 % are wasted [2]. Malnutrition is the underlying cause of death among 35 % of children aged <5 years [3], and could lead to irreversible damages such as cognitive impairment, chronic diseases and growth failure [4].

Therefore, malnutrition is a major problem for children and especially for HIV-infected children since it creates a vicious circle with HIV infection. Indeed, on the one hand, malnutrition worsens HIV disease as it has similar effects on the immune system as HIV infection. For example, among malnourished people, lymphoid tissues are damaged, and CD4 T-cell concentration is decreased [5]. Deficiencies in vitamins and minerals contribute to oxidative stress, which can accelerate immune cell death [6] and increase HIV replication [7]. On the other hand, HIV infection increases the risk of malnutrition, because of a high pro-inflammatory cytokine activity which can cause growth impairment among children [8]. HIV-related opportunistic infections such as persistent diarrhoea or oral and oesophageal candidiasis have a negative impact on nutritional status among children [9]. HIV infection can also indirectly affect the child’s nutritional status, when it has an impact on the child’s social environment. In some contexts, when HIV concerns the most productive members of the family, the household economic capacities and the agricultural production are reduced, leading to a situation of food insecurity [10]. Furthermore, poor weaning practices among HIV-infected mothers can also have an impact on the child’s nutritional status [11].

Thus, malnutrition is a common complication among HIV-infected children. Low weight-for-age has been reported in up to 50 % of untreated HIV-infected children in resource-limited settings [12]. Among children with severe malnutrition, mortality risk is three times higher in HIV-infected children than in non-HIV-infected children [13]. Thus, nutritional care is fully part of the paediatric HIV healthcare package. The World Health Organisation recommends that an asymptomatic HIV-infected child should increase his energy requirements by 10 %, compared to a non-infected child; this is extended to 20 to 30 % during symptomatic HIV infection or episodes of opportunistic infections, and up to 50 to 100 % when a severe malnutrition episode occurs [14]. However, the burden of malnutrition remains difficult to quantify in HIV-infected people, most of all in children. A better understanding of this problem and its associated factors is necessary to improve HIV paediatric healthcare, especially in sub-Saharan Africa. Thus, we conducted a cross-sectional study, to assess the prevalence and associated factors of acute and chronic malnutrition among HIV-infected children followed up in the HIV-care programmes in Central and West Africa funded by the Growing Up programme.

Methods

Study population

The Growing Up programme is supported by two French NGOs: Sidaction and Initiative Développement, and supports 17 associations in 10 Central and West-African countries, taking care of HIV-infected children and their families through a comprehensive approach. Twelve of the associations participated in the study, in seven African countries: Benin, Burundi, Cameroon, Côte d’Ivoire, Mali, Chad and Togo. Nine of these associations are located in capital cities and three in other major cities, mainly in urban or peri-urban areas. After HIV diagnosis, children received medical treatment (Cotrimoxazole prophylaxis, treatment of acute opportunistic infections, antiretroviral therapy [ART] if eligible according to the 2010 WHO guidelines [15], and nutritional support). Children were followed-up at least every 2 months.

Nutritional support was usually provided to severely malnourished children identified according to the sites modalities, usually composed of, either an enriched flour or flour-sugar-oil mixture, or ready-to-use therapeutic foods such as Plumpy nut. For every centre, nutritional support was mainly used for children under two years of age to assist the weaning period. No specific nutritional protocol was defined for older children. The nutritional assessment was not yet routinely implemented at the time of the survey.

Data from each centre were collected and entered into a database with the formal approval of each participating clinical site. There were neither extra exams nor blood
draws, nor extra data collection compared to the standard of care offered in each site. This study has been conducted in accordance with the principles of the Declaration of Helsinki of the World Medical Association. Parent’s verbal consent was collected during the conduct of the study, and all data records analysed in the database were anonymized.

Study design
A cross-sectional study was conducted between September and December 2011 among all HIV-infected children enrolled in 12 of the Growing Up Programme partnering associations. Children included in the study were those with a confirmed HIV-infection (a positive serology for children older than 18 months, or a positive polymerase chain reaction [PCR] whatever the age), aged between 2 and 19 years old, ART-treated or not, with available data for gender, age, weight and height and HIV care at the time of the survey, and who had been seen at least once in the programme during the study period.

Data management and variables
Data collection was standardised for each participating site, with a fact sheet. Data were collected during the follow-up routine visits and extracted from the medical records to be further centralised in a global database. Several types of data were collected: weight and height, measured during the survey visit according to the WHO recommendations [14], age during the survey expressed in categorical form (2–5, [5–10], and [10–19] years), the last CD4 count in cells/µL or in % less than 6 months before the study, clinical stage defined by the 2006 WHO guidelines [16], orphan status, information on HIV treatment, type of ART regimen and its duration (more or less than 6 months) and cotrimoxazole prophylaxis, and the type of the nutritional support (flour, powdered milk, solid or semi-solid foods, or Ready-to-Use Therapeutic Food [RUTF]) received during the study period and during the last six months prior to the study period. If a child had received at least one nutritional support before the study, we hypothesised that he had suffered from malnutrition and created a variable “malnutrition history”. CD4 was used in percentage for children older than 18 months, or a positive polymerase chain reaction [PCR] whatever the age), aged between 2 and 19 years old, ART-treated or not, with available data for gender, age, weight and height and HIV care at the time of the survey, and who had been seen at least once in the programme during the study period.

To define malnutrition, several anthropometric indicators are used according to WHO definitions: Height-for-Age, for children up to 19 years, Weight-for-Height for children < 5 years and BMI-for-Age for children ≥ 5 years, and Weight-for-age, for children < 10 years. These indicators are standardised using Z-scores, which quantify how many Standard Deviations (SDs) child’s weight and height is from the median value of a child of the same age and sex, in a reference population. For this analysis, we used the 2006 WHO growth charts for children < 5 [17], and the 2007 WHO growth charts for children ≥ 5 [18]. Each indicator allows to define three types of malnutrition: wasting when Weight-for-Height Z-score (WHZ) or BMI-for-Age Z-score (BAZ) < -2 SD, stunting when Height-for-Age Z-score (HAZ) < -2 SD, and underweight when Weight-for-Age Z-score (WAZ) < -2 SD. A child is defined as moderately malnourished if the Z-score is between -3 and -2 SD, and severely malnourished if the Z-score < -3 SD. Z-scores were calculated using WHO Anthro Software (version 3.2.2, January 2011) and WHO AnthroPlus.

In this study, we combined these indicators to define three categories of malnutrition: (1) acute malnutrition defined by WHZ or BAZ < -2 SD and HAZ ≥ -2 SD; (2) chronic malnutrition defined by WHZ/BAZ ≥ -2 SD and HAZ < -2 SD, and (3) mixed malnutrition as WHZ/BAZ < -2 SD and HAZ < -2 SD. WAZ was not used here.

Statistical analysis
Characteristics of the HIV-infected children included were first described by age group, then by the type of malnutrition (acute, chronic, and mixed malnutrition).

Comparisons were made using the Pearson χ2 test for qualitative variables and the Kruskal-Wallis test for quantitative variables. Prevalences of malnutrition according to the three anthropometric indicators were calculated with their 95% confidence interval. A multinomial regression model was fitted to study the associated factors to the three types of malnutrition. All explanatory variables with P < 0.25 in bivariate analyses were selected for multivariate analyses. Potential explanatory variables included age group, gender, immunodeficiency for age, history and duration on ART, malnutrition history, orphan status, cotrimoxazole prophylaxis and country. Missing data were conserved in the analysis, creating a separate modality. Because WHO clinical stage is determined by severe clinical manifestations including malnutrition status [16], we chose to exclude this variable from multivariate analyses.

Results
Characteristics of the population
Between September and December 2011, 2027 children were seen in the 12 participating centres of the Growing up Programme, representing more than 90% of the active files. Among them, 1407 (69%) had a confirmed diagnosis of HIV-infection. Of these children, 22% were excluded for age criteria and 35% for missing data. Finally, 1350 HIV-infected children were included in our study (Fig. 1). Their median age was 10 years
interquartile range [IQR] = [7–13]), 49 % were girls, 60 % were orphans for one or both parents, 77 % were on cotrimoxazole prophylaxis and 80 % were on ART for a median duration of 36 months (IQR = [18–61]). Of these children, 22 % had reached WHO clinical stage III or IV of HIV disease and 17 % were severely immunodeficient. Among the 237 children not on ART at the time of the study, 13 % were eligible (stage 3 or 4, or severely immunodeficient). More than 55 % of the included children did not receive any nutritional support at the time of the study or in the past 6 months (Table 1). Among the 45 % of children receiving nutritional support at inclusion, less than 2 % had received RUTF; and solid or semi-solid foods were the most frequently used (>80 %).

Except for gender, all children characteristics differed significantly according to age groups (Table 1). More than half of the children between 2 and 5 years had missing CD4 data. The 2–5 and 5–10 years groups were at a more advanced clinical stage of HIV disease than the 10–19 years group (25 % vs 19 % at clinical stage III or IV, p = 0.002). Compared with the 5–10 and 10–19 years groups, the 2–5 years group had received more important nutritional support prior to the study (19 % vs 12–13 % with at least 3 supports, p < 0.001) and also during the study (11 % vs 5 % with 3 supports, p < 0.001). The youngest children were also less often orphans compared with older children (71 % of 2–5 years no orphans vs 51 % of 5–10 years vs 23 % of 10–19 years, p < 0.001) (Table 1).

**Prevalence of malnutrition**

In the overall study population, 42 % of children were malnourished with 123 children (9 %, 95% CI = [6–12]) suffering from acute malnutrition, 344 (26 %, 95% CI = [23–28]) from chronic malnutrition, and 100 (7 %, 95% CI = [5–10]) from mixed malnutrition (Fig. 1). In other words, 16 % of children were wasted and 33 % were stunted with, in both cases, 36 % of them severely malnourished.

The prevalence of malnutrition differed significantly by age. Among children aged 2–5 years, half were malnourished, and we observed the highest rate of chronic malnutrition among this age group reaching 37 % (compared to 24 % in both 5–10 and 10–19 year old groups). Children aged 5–10 years were malnourished in 36 % of cases, and children aged 10 to 19 years in 44 % (Table 2).

Among the non-malnourished children, 45 % received at least one nutritional support before or during the study. Among the malnourished children at the time of the survey, whatever the type of malnutrition, 53 % received at least one nutritional support before or during the study. This nutritional support was more frequent for children between 2 and 5 years of age with no malnutrition, acute or chronic malnutrition, compared with older children (p < 0.001, p = 0.001 and p = 0.005 respectively). Children with mixed malnutrition and aged between 5 and 10 had more frequently a nutritional support compared with the other age groups (p = 0.025). Also, among children who had a nutritional
| Variables                                      | Age group in years | P-value* | Total (n = 1350) |
|-----------------------------------------------|--------------------|----------|------------------|
|                                               | [2–5] (n = 161) | [5–10] (n = 505) | [10–19] (n = 684) |
| Gender, n, %                                  |                    |          |                  |
| Female                                        | 78 48 254 50 333 49 | 665 49 |
| Male                                          | 83 52 251 50 351 51 | 685 51 |
| CD4%, median, IQR†                            | 31 24–37           |          |                  |
| CD4/mm3, median, IQR‡                         |                    |          |                  |
| Immunodeficiency by age§, n, %                |                    |          |                  |
| No immunodeficient                            | 57 35 363 72 382 56 | 802 59 |
| Moderate                                      | 15 9 52 10 129 19  | 196 15 |
| Severe                                        | 6 4 65 13 152 22 | 223 17 |
| Missing                                       | 83 52 25 5 21 3  | 129 10 |
| WHO Clinical stage§, n, %                    |                    |          |                  |
| I                                             | 70 44 223 44 380 56 | 673 50 |
| II                                            | 48 30 137 27 157 23 | 342 25 |
| III                                           | 25 16 89 18 98 14 | 212 16 |
| IV                                            | 16 10 40 8 34 5 | 90 7 |
| Missing                                       | 2 1 16 3 15 2 | 33 2 |
| Nutritional support within 6 months prior to the study§, n, % | | <0.001 | |
| None                                          | 59 37 246 49 399 58 | 704 52 |
| 1 support                                     | 54 34 152 30 144 21 | 350 26 |
| 2 supports                                    | 15 9 34 7 51 8 | 100 7 |
| 3–4 supports                                  | 31 19 65 13 82 12 | 178 13 |
| Missing                                       | 2 1 8 2 8 1 | 18 1 |
| Nutritional support during the study§, n, %   |                    |          |                  |
| None                                          | 68 42 261 52 418 61 | 747 55 |
| 1 support                                     | 55 34 161 32 157 23 | 373 28 |
| 2 supports                                    | 18 11 53 11 72 11 | 143 11 |
| 3 supports                                    | 17 11 25 5 31 5 | 73 5 |
| Missing                                       | 3 2 5 1 6 1 | 14 1 |
| Treatment, n, %                               |                    |          |                  |
| No treatment                                  | 4 3 13 3 14 2 | 31 2 |
| Cotrimoxazole only                            | 40 25 107 21 73 11 | 220 16 |
| ART only                                      | 25 16 107 21 131 19 | 263 20 |
| Cotrimoxazole + ART                           | 90 56 271 54 459 67 | 820 61 |
| Missing                                       | 2 1 7 1 7 1 | 16 1 |
| Orphans status, n, %                          |                    |          |                  |
| Single (father deceased)                      | 32 20 110 22 136 20 | 278 21 |
| Single (mother deceased)                      | 12 8 71 14 130 19 | 213 16 |
| Double                                        | 2 1 62 12 248 36 | 312 23 |
| No orphan                                     | 115 71 255 51 158 23 | 528 39 |
| Missing                                       | 0 0 7 1 12 2 | 19 1 |
| Country, n, %                                 |                    |          |                  |
| Benin                                         | 5 3 25 5 18 3 | 48 4 |

<sup>1</sup> IQR: interquartile range
<sup>2</sup> CD4: cluster of different different T-cell counts
<sup>3</sup> WHO: World Health Organization

*P-values were calculated using the Wilcoxon rank sum test for continuous variables and Fisher’s exact test for categorical variables.
support, most of them were supported both before and during the study, whatever the malnutrition degree (Table 3).

Factors associated with acute malnutrition
More than half of children suffering from acute malnutrition were aged >10 years; 63% were boys, 37% were known to be either moderately or severely immunodeficient and 27% were reported to be at a WHO clinical stage III or IV, although unexplained moderate or severe malnutrition are criteria for classifying an HIV-infected child at these stages. Furthermore, 63% of children presenting acute malnutrition didn’t receive any nutritional support during the study. Moreover, 66% were initiated on ART for more than 6 months and 20% were not yet receiving ART (Table 4).

In univariate analysis, acute malnutrition was significantly twice as high in boys as in girls, and in children with severe immunodeficiency compared to those not (OR = 2.13, 95% CI = [1.44–3.16] and OR = 2.27, 95% CI = [1.43–3.62] respectively) (Table 5).

In the adjusted analysis for age group, sex, country, immunodeficiency, malnutrition history, duration on ART and orphan status, boys were twice more likely malnourished than girls (aOR = 2.27, 95% CI = [1.52–3.41]), as well severely immunodeficient children compared to non-immunodeficient children (aOR = 2.07, 95% CI = [1.25–3.42]), and non-ART-treated children compared with those on ART for more than 6 months (aOR = 1.70, 95% CI = [1.01–2.84]) (Table 5).

Factors associated with chronic malnutrition
Among children suffering from chronic malnutrition, 47% were aged >10 years, 55% were boys, 30% were moderately or severely immunodeficient and 28% were reported to be at an advanced clinical stage (III or IV). Among these children, 43% hadn’t received any nutritional support during the 6 months prior to the study, 9% were recently initiated on ART and 18% were not receiving ART (Table 4).

In univariate analysis, chronic malnutrition was significantly twice as low in children older than 5 years of age as in younger children ([5–10] vs. [2–5]: OR = 0.51, 95% CI = [0.34–0.75], [10–19] vs. [2–5]: OR = 0.57, 95% CI = [0.39–0.84]), higher in boys compared to girls (OR = 1.50, 95% CI = [1.16–1.94]), in children with missing immunological data (OR = 1.76, 95% CI = [1.17–2.65]), in children ART-initiated for less than 6 months compared to children on ART for more than 6 months (OR = 1.74, 95% CI = [1.06–2.85]), and in those who had an history of malnutrition (OR = 1.73, 95% CI = [1.34–2.23]) (Table 5).

In the adjusted analysis for age group, sex, country, immunodeficiency, malnutrition history, duration on ART and orphan status, the risk of chronic malnutrition was reduced in children aged 5–10 years compared to those aged 2–5 years (aOR = 0.61, 95% CI = [0.38–0.99]). On the other hand, chronic malnutrition was more likely among boys compared to girls (aOR = 1.56, 95% CI = [1.20–2.03]). Children who had received nutritional support within the 6 months prior to the study were

### Table 1 Characteristics of the 1350 HIV-infected children of the study population according to age groups (Continued)

| Malnutrition degree | Age group in years (n-value <0.001*) |
|---------------------|------------------------------------|
| Burundi             | (n = 161)                          |
| Cameroun            | (n = 505)                          |
| Côte d’Ivoire       | (n = 684)                          |
| Mali                | (n = 1350)                         |
| Tchad               | (n = 1350)                         |
| Togo                | (n = 1350)                         |

*Chi-square test for qualitative variables, Kruskal-Wallis test for quantitative variables

### Table 2 Prevalence of malnutrition among the 1350 HIV-infected children of the study population according to age groups

| Malnutrition degree | Age group in years (n-value <0.001*) |
|---------------------|------------------------------------|
| Acute malnutrition  |                                    |
| Chrono malnutrition |                                    |
| Mixed malnutrition  |                                    |

*Chi-square test for the comparison of malnutrition prevalence according to age groups

acute malnutrition: Weight-for-Age Z-score (WHZ)/BMI-for-age Z-score (BAZ) < -2 SD and Height-for-Age Z-score (HAZ) ≥ -2 SD, chronic malnutrition: WHZ/BAZ ≥ -2 SD and HAZ < -2 SD, mixed malnutrition: WHZ/BAZ and HAZ < -2 SD
more likely malnourished compared to those not receiving any support (aOR = 1.99, 95% CI = [1.43–2.77]) (Table 5).

Factors associated with mixed malnutrition
Among children suffering from mixed malnutrition, 87% were aged more than 10 years. There were 67% of boys, 45% were moderately or severely immunodeficient and 32% were at an advanced clinical stage. Furthermore, 54% hadn’t received any nutritional support during the study and 51% hadn’t received any during the 6 months prior to the study. Moreover, 12% were recently initiated on ART and 12% were not receiving ART (Table 4).

In univariate analysis, mixed malnutrition was significantly twice as low in children aged 5 to 10 years of age as in younger children (OR = 0.32, 95% CI = [0.15–0.69]), higher in boys compared to girls (OR = 2.50, 95% CI = [1.61–3.88]), as well as in children with severe immunodeficiency (OR = 3.22, 95% CI = [2.01–5.51]), and in children ART-initiated for less than 6 months compared to children on ART for more than 6 months (OR = 2.40, 95% CI = [1.21–4.78]) (Table 5).

In the adjusted analysis for age group, sex, country, immunodeficiency, malnutrition history, duration on ART and orphan status, we observed lower risks of mixed malnutrition in children aged 5–10 years compared to 2–5 years (aOR = 0.34, 95% CI = [0.14–0.84]). Risks of mixed malnutrition were higher among boys compared to girls (aOR = 2.60, 95% CI = [1.64–4.10]) and among severely immunodeficient children compared to non immunodeficient children (aOR = 2.43, 95% CI = [1.40–4.23]) and in those on ART for less than 6 months compared to children on ART for more than 6 months (aOR = 2.54, 95% CI = [1.17–5.55]) (Table 5).

Discussion
In this cross-sectional study conducted in 2011 among 1350 HIV-infected children receiving paediatric care in 12 associations of the Growing up Programme in sub-Saharan Africa, we documented a high prevalence of 42% of malnutrition, with acute, chronic and mixed...
Table 4 Baseline characteristics of the study population according to the type of malnutrition. N = 1350

| Variables                                      | Acute malnutrition* | Chronic malnutrition | Mixed malnutrition | Study population |
|------------------------------------------------|---------------------|-----------------------|--------------------|------------------|
|                                                 | (N = 123)           | (N = 344)             | (N = 100)          | (N = 1350)       |
| Age group in years                              |                     |                       |                    |                  |
| [2–5]                                          | 10 8                | 59 17                 | 13 13              | 161 12           |
| [5–10]                                         | 44 36               | 122 35                | 17 17              | 505 37           |
| [10–19]                                        | 69 56               | 163 47                | 70 70              | 684 51           |
| Gender                                         |                     |                       |                    |                  |
| Female                                         | 45 37               | 155 45                | 33 33              | 665 49           |
| Male                                           | 78 63               | 189 55                | 67 67              | 685 51           |
| Immunodeficiency for age‡                      |                     |                       |                    |                  |
| No immunodeficient                             | 70 57               | 195 57                | 45 45              | 802 59           |
| Moderate                                       | 13 11               | 46 13                 | 14 14              | 196 15           |
| Severe                                         | 33 27               | 57 17                 | 31 31              | 223 17           |
| Missing                                        | 7 6                 | 46 13                 | 10 10              | 129 10           |
| WHO clinical stage‡                            |                     |                       |                    |                  |
| I                                              | 50 41               | 139 40                | 43 43              | 673 50           |
| II                                             | 34 28               | 101 29                | 23 23              | 342 25           |
| III                                            | 16 13               | 73 21                 | 24 24              | 212 16           |
| IV                                             | 17 14               | 24 7                  | 8 8                | 90 7             |
| Missing                                        | 6 5                 | 7 2                   | 2 2                | 33 2             |
| Nutritional support within 6 months prior to the study‡ |                     |                       |                    |                  |
| None                                           | 69 56               | 148 43                | 51 51              | 704 52           |
| 1 support                                      | 21 17               | 100 29                | 19 19              | 350 26           |
| 2 supports                                     | 12 10               | 29 8                  | 9 9                | 100 7            |
| 3–4 supports                                   | 18 15               | 65 19                 | 20 20              | 178 13           |
| Missing                                        | 3 2                 | 2 1                   | 1 1                | 18 1             |
| Nutritional support during the study‡          |                     |                       |                    |                  |
| None                                           | 77 63               | 161 47                | 54 54              | 747 55           |
| 1 support                                      | 21 17               | 114 33                | 22 22              | 373 28           |
| 2 supports                                     | 17 14               | 36 11                 | 12 12              | 143 11           |
| 3 supports                                     | 6 5                 | 30 9                  | 11 11              | 73 5             |
| Missing                                        | 2 2                 | 3 1                   | 1 1                | 14 1             |
| Duration of ART                                |                     |                       |                    |                  |
| <6 Months                                      | 11 9                | 30 9                  | 12 12              | 94 7             |
| >6 Months                                      | 81 66               | 245 71                | 71 71              | 979 73           |
| No yet started                                 | 25 20               | 63 18                 | 12 12              | 237 18           |
| Unknown                                        | 6 5                 | 6 2                   | 5 5                | 40 3             |
| Cotrimoxazole prophylaxis                      |                     |                       |                    |                  |
| Yes                                            | 101 82              | 271 79                | 74 74              | 1040 77          |
| No                                             | 21 17               | 69 20                 | 26 26              | 294 22           |
| Unknown                                        | 1 1                 | 4 1                   | 0 0                | 16 1             |
malnutrition which were 9 %, 26 % and 7 % respectively. This study provides also a snapshot of the nutritional practices in field conditions. Among the malnourished children in this study, more than half of the children didn’t receive any nutritional support during the study or within the 6 months prior to the study. Regarding associated factors, we report higher prevalence of malnutrition, whatever the type, among boys compared to girls. Children between 2 and 5 years had more often chronic or mixed malnutrition compared to children between 5 and 10 years. Furthermore, as a marker of HIV-disease progression, children with severe immunodeficiency or recently initiated on ART were more at risk for acute or mixed malnutrition.

Our findings show overall, a high rate of malnutrition in such a healthcare programme. Comparisons with others studies are difficult because of the differences between study population and definitions of malnutrition. Among the malnourished children in this study, more than half of the children didn’t receive any nutritional support during the study or within the 6 months prior to the study. Regarding associated factors, we report higher prevalence of malnutrition, whatever the type, among boys compared to girls. Children between 2 and 5 years had more often chronic or mixed malnutrition compared to children between 5 and 10 years. Furthermore, as a marker of HIV-disease progression, children with severe immunodeficiency or recently initiated on ART were more at risk for acute or mixed malnutrition.

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In our study, orphan status was not associated with malnutrition, which is concordant with other results among HIV-infected children in sub-Saharan Africa [28–30], although other results have reported otherwise [31]. In our context, we can explain our observation by the specific healthcare received by orphaned children in participating associations, reducing differences between orphans and non orphans.

We didn’t find any association between cotrimoxazole prophylaxis and growth in our study, whereas other studies have reported positive effects of such prophylaxis on growth. A study conducted with the Zambian CHAP trial in HIV-infected children, who had not yet received ART, reported that cotrimoxazole prophylaxis slowed decrease in weight and height [32].

This study presents several limitations. First, children included in this study had access to paediatric HIV healthcare, mostly in urban areas where the standard of care may be higher than that offered in rural areas, we found also an association between recent ART initiation, marker of the HIV-disease progression and mixed malnutrition. We advise caution in interpreting this result since we are unable to access which came first, malnutrition or ART initiation. However, considering previous studies describing the benefits of ART on weight and height gain [24–27]), we hypothesise that these children were probably initiated on ART based on clinical criteria such as malnutrition. Furthermore, we found that non-ART-treated children were more likely to present acute malnutrition compared to ART-treated children.

Similarly, as a marker of malnutrition, children who received a nutritional support six months prior the survey suffered more from chronic malnutrition than those who didn’t received any nutritional support. These children have probably been experiencing malnutrition problems for several months, perhaps several years, leading to chronic malnutrition, which is difficult to reverse.

Table 5 Factors associated with malnutrition (acute, chronic and mixed), univariate and multivariate multinomial logistic regressions. N = 1350

| Variable                        | Acute malnutrition* (N = 123) | Chronic malnutrition (N = 344) | Mixed malnutrition (N = 100) |
|---------------------------------|--------------------------------|--------------------------------|------------------------------|
|                                 | OR† 95% CI aOR† 95% CI         | OR† 95% CI aOR† 95% CI         | OR† 95% CI aOR 95% CI        |
| Age group in years              |                                |                                |                              |
| [2–5]                           | 1 - 1 -                       | 1 - 1 -                        | 1 - 1 -                      |
| [5–10]                          | 1.08 (0.52–2.24) 0.91 (0.39–2.15) | 0.51 (0.34–0.75) 0.61 (0.38–0.99) | 0.32 (0.15–0.69) 0.34 (0.14–0.84) |
| [10–19]                         | 1.43 (0.70–2.89) 1.57 (0.66–3.78) | 0.57 (0.39–0.84) 0.78 (0.47–1.29) | 1.11 (0.59–2.11) 1.32 (0.56–3.09) |
| Gender (Male/Female)            | 2.13 (1.44–3.16) 2.27 (1.52–3.41) | 1.50 (1.16–1.94) 1.56 (1.20–2.03) | 2.50 (1.61–3.88) 2.60 (1.64–4.10) |
| Immunodeficiency by age§        |                                |                                |                              |
| No immunodeficient              | 1 - 1 -                        | 1 - 1 -                        | 1 - 1 -                      |
| Moderate                        | 0.75 (0.40–1.39) 1.19 (0.47–3.02) | 0.94 (0.65–1.38) 0.89 (0.60–1.31) | 1.24 (0.66–2.34) 0.99 (0.51–1.91) |
| Severe                          | 2.27 (1.43–3.62) 2.07 (1.25–3.42) | 1.41 (0.98–2.03) 1.40 (0.96–2.06) | 3.32 (2.01–5.51) 2.43 (1.40–4.23) |
| Missing                         | 0.75 (0.33–1.69) 0.61 (0.23–1.63) | 1.76 (1.17–2.65) 1.32 (0.78–2.23) | 1.66 (0.80–3.44) 1.19 (0.47–3.02) |
| Duration of ART                 |                                |                                |                              |
| ≥ 6 months                      | 1.93 (0.95–3.90) 1.80 (0.84–3.89) | 1.74 (1.06–2.85) 1.58 (0.93–2.67) | 2.40 (1.21–4.78) 2.54 (1.17–5.55) |
| No yet started                  | 1.31 (0.81–2.13) 1.70 (1.01–2.84) | 1.09 (0.78–1.53) 1.11 (0.78–1.58) | 0.72 (0.38–1.36) 1.11 (0.56–2.18) |
| Missing                         | 1.87 (0.74–4.74) 2.48 (0.92–6.63) | 0.62 (0.25–1.54) 0.69 (0.27–1.77) | 1.78 (0.66–4.83) 2.34 (0.79–6.91) |
| Malnutrition history (Yes/No)§  | 0.95 (0.64–1.39) 1.23 (0.75–2.04) | 1.73 (1.34–2.23) 1.99 (1.43–2.77) | 1.23 (0.81–1.87) 1.67 (0.96–2.89) |
| Orphan status (Yes/No)          | 0.91 (0.62–1.34) 0.84 (0.55–1.29) | 0.93 (0.72–1.20) 1.03 (0.77–1.37) | 1.58 (1.00–2.49) 1.39 (0.83–2.32) |
| Treatment Cotrimoxazole (/No)   |                                |                                |                              |
| Yes                             | 1.44 (0.88–2.37) - -          | 1.18 (0.86–1.61) - -           | 0.85 (0.53–1.37) - -         |
| Missing                         | 0.77 (0.10–6.27) - -          | 0.94 (0.29–3.05) - -           | <0.001 - - - -              |

*Acute malnutrition: Weight-for-Age Z-score (WHZ)/BMI-for-age Z-score (BAZ) < -2 SD and Height-for-Age Z-score (HAZ) ≥ -2 SD, Chronic malnutrition: WHZ/BAZ ≥ -2 SD and HAZ < -2 SD, Mixed malnutrition: WHZ/BAZ and HAZ < -2 SD
†OR = Odds Ratio, aOR = adjusted Odds Ratio, analyses adjusted on clinical centres
§WHO 2006 guidelines
¶Nutritional support 6 months prior the study
||Orphan status including both double and single orphans
making results difficult to extrapolate to rural areas. Second, we excluded the children <2 years, because too few respected the inclusion criteria. However, this population is precisely known to be more vulnerable and having more malnutrition problems [33, 34]. Furthermore, since 50 % of HIV-infected children not initiated on ART die before their second birthday [34], the sickest children could not have survived until the survey period, leading to a survivor bias. So, the selection of the study population is not representative of a birth cohort of HIV-infected children in sub-Saharan Africa, leading to an underestimation of the prevalence of malnutrition. Third, there are possible measurement errors in weight and height; we limited this by using a standard measurement protocol for all centres, following the WHO recommendations [14]. However, peripheral oedema, sign of severe malnutrition, was not collected, despite their effect on increasing artificially weight. Furthermore, because of our definition of malnutrition (acute, chronic and mixed), 20 children with a low weight-for-age were not defined as malnourished and were misclassified in the analyses. Finally, the cross-sectional study design didn’t allow to establish a causal relationship between malnutrition and explanatory variables.

Nevertheless, the study included nearly all children enrolled in the 12 participating associations of the Growing Up Programme representing as best as possible HIV-infected children enrolled in HIV care programmes in West and Central Africa. Data collection was of high quality in this study context, with more than 97 % of anthropometric data available. Most of all, very few studies have reported the nutritional practices in HIV-infected malnourished children, and although practices are not detailed in our study, it highlights this gap and the need to focus on these interventions in such children. Finally, despite the possible biases that could have all underestimated the prevalence, we hypothesize that we provided a conservative estimate of the prevalence of malnutrition in a large sample size of Central and West African children, which can give us an idea of the picture of the burden of malnutrition among HIV-infected children in this region.

As a result, we report that anthropometric measurements are not enough routinely performed in the field conditions, and nutritional supplementation is not optimally used and monitored in this context. Indeed, we have seen that close to half of malnourished children didn’t receive any nutritional support, before as well as during the survey, whereas a substantial part of non-malnourished children still had a nutritional support at the moment of the survey. However, taking better into account data on growth in HIV-care programmes could be major to improve long-term paediatric HIV-care.

**Conclusion**

In conclusion, the prevalence of malnutrition remains high for HIV-infected children in sub-Saharan Africa, even in an HIV care programme supposed to have a high standard of care. A better acknowledgement of this problem is needed, that should lead to a better healthcare management of HIV-infected children, with active routine anthropometric measurements easy to perform to allow an earlier detection of malnutrition leading to an appropriate nutritional package. Our study strengthens the World Health Organization recommendation on the need for a nutritional assessment and support that should be an integral part of the care plan of HIV-infected children [35]. Indeed, an early detection of growth impairment could detect, for example, poor treatment response, poor adherence to treatment, and could prevent morbidity and mortality risks. Further studies about associated factors with malnutrition, such as differences in sex need to be examined more closely in prospective designs [23]. Moreover, food supplementation and multivitamin use may improve the nutritional status of the children. Finally, nutritional interventions should be tailored and assessed to improve growth, especially at time of ART initiation that could lead to an optimisation of their clinical response and survival of ART-treated children.

**Competing interests**

The authors declare that they have no competing interests.

**Authors’ contribution**

JL, SD and VL contributed to the study design and statistical analyses. JL was in charge of the statistical analysis of the project, and of the first drafting of the manuscript, which all authors subsequently reviewed, edited and approved. DM, CT and RZ are in charge of the Growing Up Programme. AA, CH, LN, GS, RK, ES, TR, AN, PS, AK, AB, and GG were involved in the conduct of the field HIV programs funded by the Growing Up Programme. All authors read and approved the final manuscript.

**Acknowledgments**

The authors would like to thank all the participating children and their families, all the healthcare workers of the sites involved in the Growing up Programme, Sidaction and ID for their funding. All the members of the Growing Up Working Group: Anésie Adoron (RACINES, Bénin), Captolène Habarugira (ANSS, Burundi), Léoncie Nicimpaye (APECOS, Burundi), Goreth Serurakuba (SWAA-Burundi), Rosine Kwaye (SWAA Littoral, Cameroun), Edith Sare (CSAS, Côte d’Ivoire), Tiefing Konate (ARCAD, Mali), Abdoulaye Nlimage (AKS, Mali), Philemon Saina (ADN, Tchad), Akossiwa Kpade (AMC, Togo), André Bassuka (EVT, Togo), Gustave Gouguyuyor (CRIPS, Togo).

**Source of funding**

This Study was funded by Sidaction-Ensemble contre le SIDA and Initiative Développement in France. Julie Jesson is a fellow of the French Ministry of Higher Education and Research, Bordeaux University, France.

**Author details**

1. Inserm, Centre Inserm U897 - Épidémiologie - Biostatistiques, Bordeaux, France.
2. Centre de Recherche Inserm U897, Institut de Santé Publique, d’Épidémiologie et de Développement (ISPEd), Université Bordeaux Segalen Case 11, 146 rue Léo Saignat, 33076 Bordeaux, Cedex, France.
3. Growing Up Programme - Sidaction & Initiative Développement, Paris, France.
4. RACINES (Recherches Actions Communautaires Initiatives pour un Nouvel Espoir), Cotonou, Bénin.
5. ANSS (Association Nationale de Soutien aux Séropositifs et
maladies du Sida), Bujumbura, Burundi. 3APECOS (Association de Prise en Charge des Orphelinats du Sida ), Bujumbura, Burundi. 2SWA (Society for Women against AIDS in Africa) - Burundi, Bujumbura, Burundi. 2SLL (Société pour les femmes contre les VIH et le sida), Bujumbura, Burundi. 2SLLA (Société pour les femmes contre les VIH et le sida, Bujumbura, Burundi. 2SWA (Society for Women against AIDS in Africa) - Douala, Cameroon. 3CSAS (Centre Solidarité Action Sociale), Bouaké, Ivory Coast. 3ARCAD (Association de Recherche de Communication et d’Accompagnement à Domicile des personnes vivant avec le VIH et le sida), Bamako, Mali. 6AKS (Association Kenedougou Solidarité ), Sikasso, Mali. 7ADN (Association Djenandoum Naassson), Moundou, Chad. 8AMC (Aide Médicale et Chanté), Loné, Togo. 9ETV (Espoir Vie Togo), Loné, Togo. 10CRIPS (Centre de Recherche de d’Information Pour la Santé ) - Loné, Togo, Togo.

Received: 29 May 2014 Accepted: 18 May 2015

Published online: 26 May 2015

References

1. UNAIDS. UNAIDS report on the global AIDS. Geneva, Switzerland. UNAIDS; 2013.

2. United Nations Children’s Fund, World Health Organization, and World Bank. UNICEF-World Bank Joint Child Malnutrition Estimates. New York, USA: UNICEF, Geneva, Switzerland, WHO; and Washington DC, USA: World Bank; 2012.

3. World Health Statistics 2012. Geneva, Switzerland: World Health Organization; 2012.

4. Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, et al. Maternal and child undernutrition: consequences for adult health and human capital. Lancet. 2008;371(9609):340–57.

5. Cunningham-Rundles S, McNeeley DF, Moon A. Mechanisms of nutrient modulation of the immune response. J Allergy Clin Immunol. 2005;116(1):119–28.

6. Romero-Alvita D, Roche E. The keys of oxidative stress in acquired immune deficiency syndrome apoptosis. Med Hypotheses. 1998;51(2):169–73.

7. Allard JP, Aghdassi E, Chau J, Tam C, Kovacs OM, Salti IE, et al. Effects of vitamin E and C supplementation on oxidative stress and viral load in HIV-infected subjects. AIDS. 1998;12(13):1653–9.

8. Johann-Liang R, O’Neil L, Crevia J, Haller I, Giunta Y, Licholai T, et al. Energy balance, viral burden, insulin-like growth factor-1, interleukin-6 and growth impairment in children infected with human immunodeficiency virus. AIDS. 2000;14(6):683–90.

9. Trehan I, O’Hare BA, Phiri A, Heikens GT. Challenges in the Management of HIV-Infected Malnourished Children in Sub-Saharan Africa. AIDS Res Treat. 2012;2012:79076.

10. Anema A, Vogenthaler N, Frongillo EA, Kadiyala S, Weiser SD. Food insecurity and HIV/AIDS: current knowledge, gaps, and research priorities. Curr HIV/AIDS Rep. 2009;6(4):224–31.

11. Saloojee H, De Maayer T, Garenne ML, Kahn K. What is new? Investigating the impact of childhood malnutrition on adult health in South Africa. Scand J Public Health Suppl. 2007;99:96–105.

12. Prendergast A, Walker AS, Mulenga V, Chintu C, Gibb DM. Improved growth and anemia in HIV-infected African children taking cotrimoxazole prophylaxis. Clin Infect Dis. 2011;52(7):953–6.

13. Spira R, Lepage P, Mselati P, Van De Perre P, Louy L, Simonon A, et al. Natural history of human immunodeficiency virus type 1 infection in children: a five-year prospective study in Rwanda. Mother-to-Child HIV-1 Transmission Study Group. Pediatrics. 1999;104(S), e5.

14. Newell ML, Coovadia H, Huda S, Rollins N, Gaird P, Dabis F. Mortality of infected and uninfected infants born to HIV-infected mothers in Africa: a pooled analysis. Lancet. 2004;364(9441):1236–43.

15. WHO. Guidelines for an integrated approach to the nutritional care of HIV-infected adults and other orphaned and vulnerable young children. Geneva, Switzerland: World Health Organization; 2009.

16. WHO. Antiretroviral therapy for HIV infection in infants and children: Towards universal access. Recommendations for a public health approach, 2010 revision. Geneva, Switzerland: World Health Organization; 2010.

17. WHO. WHO case definitions of HIV for surveillance and revised clinical staging and immunological classification of HIV-related disease in adults and children. Geneva, Switzerland: World Health Organization; 2006.

18. de Onis M, Onyango AW, borghi E, siyam A, Nishida C, siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organization. 2007;85:680–7.

19. Sunguya BF, Poudel KC, Otsuka K, Yasuoka J, Milunde LB, Utasa DP, et al. Undernutrition among HIV-positive children in Dar es Salaam, Tanzania: antiretroviral therapy alone is not enough. BMC Public Health. 2011;11:869.