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Health status of adults exposed to severe acute malnutrition during childhood in the Eastern Democratic Republic of the Congo: the Lwiro cohort study

Christian Chiribagula,[1] Ghislain Bisimwa,[1] Michel P Hermans,[2] Michele Dramaix,[3] Samuel Makali ,[1] Gaylord Ngaboyeka,[1] Christine Chimanuka,[1] Corneille Lembebu,[1] Rosine Bigirinama,[1] Jonathan C Wells,[4] Pacifique Mwene-Batu [1,5]

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[1]Ecole Regionale de Santé Publique, Université Catholique de Bukavu, Bukavu, Democratic Republic of Congo
[2]Division of Endocrinology & Nutrition, Cliniques Universitaires St-Luc, Université Catholique de Louvain, Brussels, Belgium
[3]Ecole de Santé Publique, Université Libre de Bruxelles, Bruxelles, Belgium
[4]Childhood Nutrition Research Centre, Institute of Child Health, London, UK
[5]Faculty of Medicine, Université de Kaziba, Kaziba, Democratic Republic of Congo

Correspondence to
Dr Pacifique Mwene-Batu; lyabpacifique@yahoo.fr

ABSTRACT

Background While most studies of adults with a history of severe acute malnutrition (SAM) focused on survival and long-term non-communicable diseases, few studies have examined community health. The aim of this study was to compare the overall health status and its predictors between adults with a history of SAM and healthy controls in the context of Eastern Democratic Republic of the Congo using the WHO Disability Assessment Schedule (WHODAS).

Methods We evaluated 257 adults in Eastern Democratic Republic of the Congo who were treated for SAM during childhood between 1988 and 2007. They were compared with 187 age-matched and sex-matched control adults living in the same community who had not been exposed to malnutrition as a child. The main outcome was the WHODAS summary score, measuring an individual's health status in six domains of disability (household daily tasks, cognitive, mobility, self-care, social networks and social participation). A multivariable logistic regression model was used to identify the predictors of health status.

Results The median age of the participants in both groups was 20 years. The median (P25–P75) WHODAS score in SAM+ participants was 25.0 (14.6–33.3), whereas it was 8.3 (4.2–14.6) in SAM− participants ($p<0.001$). In five of the six disability domains (except individual self-care), SAM+ participants had significantly higher scores (poorer health) than SAM− participants. Consequently, 63% of SAM+ participants had a higher level of dependency compared with 16.6% of SAM− participants. Finally, being SAM+ was predictive of a higher WHODAS score (OR 8.6, 95% CI 5.4 to 13.6, $p=0.002$). In the multivariable logistic regression model, occupation, socioeconomic status and use of social networks, introduced separately in addition to SAM, remained significant but had no confounding effect on the association between SAM and WHODAS score.

Conclusion SAM during childhood has deleterious consequences on the state of health during adulthood. It is imperative to implement interventions to prevent and treat SAM during childhood to maximise adult population health.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Severe acute malnutrition (SAM) and disability are important global health issues.
⇒ While most studies on the long-term outcome of children treated for SAM focused on survival and the specific pathologies potentially linked to malnutrition, few studies have focused on long-term community health in terms of disabilities using a person-centred rather than a disease-centred approach.

WHAT THIS STUDY ADDS

⇒ This study highlights that disability is prevalent among adults previously treated for SAM, affecting various domains such as mobility, social networks and social participation, household daily tasks, and cognitive function, and contributing to a higher WHO Disability Assessment Schedule (WHODAS) score, which indicates poorer health outcomes.
⇒ SAM+ adults tended to have higher WHODAS scores (poorer health status) regardless of socioeconomic level, occupation or level of education.

INTRODUCTION

Severe acute malnutrition (SAM) is a public health problem in low-income and middle-income countries (LMICs), with costs to the global economy estimated at US$3.5 trillion per year.[1] SAM currently affects 17 million children worldwide, 27% of whom live in Africa.[1] An estimated two million annual deaths are attributable to SAM.[2]

In addition to mortality risk, SAM has serious adverse effects on the physiology of survivors, especially when it occurs in early childhood.[3 4] However, SAM does not only affect children; adults are also exposed to the long-term consequences of SAM.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Clinical assessment alone is likely to be inadequate and therefore structured assessments and interdisciplinary follow-up are crucial in SAM treatment programmes to address long-term health consequences, which are often overlooked in low-income countries.

⇒ The study advocates for regular multidisciplinary monitoring that involves various specialists for early detection and management of potential disorders in SAM survivors.

⇒ The study underscores the necessity for policymakers and funders to invest in child health initiatives for SAM as a strategy to alleviate the broader impact of extreme poverty and the associated health costs.

⇒ This approach aligns with the growing evidence that SAM treatment should be customised based on risk factors beyond mere severity measured by anthropometry.

According to studies that have examined the negative long-term effects of childhood undernutrition on behaviour and on academic and cognitive performance, survivors of undernutrition attain fewer years of education and have deficiencies in vocabulary and mathematics, along with other learning or intellectual disabilities.[5–8] This poor cognitive and academic development may lower their probability of acquiring better-paying professions, leading to reduced economic productivity during adulthood. This could create social and economic issues in disadvantaged communities, leading to the vicious circle of intergenerational poverty, which hinders the economic development of majority of low-income countries (LICs).[9] The reason for this is that childhood undernutrition affects brain development and leads to less efficient brain function, as a result of myelin deficiency, reduced dendritic branching, alteration in the function of certain neurotransmitters (serotonin and dopamine) and the presence of underdeveloped connectivity patterns.[10 11]

In the Democratic Republic of the Congo (DRC), acute malnutrition remains a major public health problem, with a prevalence still above the critical threshold of 10% in some provinces.[12] Several studies have been conducted to explore the long-term consequences of SAM in DRC in general and in South Kivu in particular.[13–17] Yet none of these studies investigated the potential long-term deleterious effects of SAM during childhood on the state of health during adulthood in terms of disabilities, which may occur on a daily basis in the community and affect everyday life in the long term.

Recently, in a cohort study (Lwiro cohort) conducted in South Kivu, it was observed that adults with a history of SAM in childhood had a higher risk of developing metabolic syndrome, visceral obesity and abnormal glucose homeostasis, compared with non-exposed community peers, 11–30 years following nutritional rehabilitation.[18] Moreover, children who had SAM had reduced human capital during adulthood. Finally, it was observed that most deaths occurred within 5 years following nutritional rehabilitation and that most of these deaths were due to infectious diseases.[19] However, while most studies of individuals with a history of malnutrition focused on survival and the specific pathologies potentially linked to malnutrition, few studies have focused on community health of those with a history of malnutrition using a person-centred rather than a disease-centred approach.

In DRC, the health status of a population is often assessed using health indicators that reflect disease-related mortality and/or morbidity (child mortality, malaria-related morbidity, etc).[20] This way of measuring health status does not consider other aspects of the individual (social, psychological) that seem to have a tangible impact on their health, especially in crisis situations related to armed conflicts and endemic malnutrition.

To measure health status, WHO has introduced the Disability Assessment Schedule 2.0 (WHODAS 2.0), which enables a person's health problems to be identified in their entirety. This may enable holistic care to be provided, given that health is not defined solely on the basis of physical or biological deficiencies.[21 22] To date, several studies have shown that WHODAS can be used in the rural health zones (HZ) of DRC.[20 23–25]

The aim of this study was to compare the overall health status and its predictors between adults with a history of SAM and healthy controls in the context of Eastern DRC from a person-centred rather than a disease-centred perspective using WHODAS 2.0.

METHODOLOGY

Study framework

The study was carried out at the Centre de Recherche en Sciences Naturelles de Lwiro (CRSN-Lwiro), in the HZs of Katana and Miti-Murhesa in South Kivu Province in DRC, which are located on the northern axis of the province, 33 km and 40 km from the town of Bukavu, respectively. The CRSN was created in 1947 and its activities are grouped under four research departments: biology, geophysics, nutrition and documentation. The nutrition department has a paediatric hospital, which between 1980 and 2000 served as the provincial referral hospital for treatment of malnutrition.[17] The main economic activities of the population in the HZs of Miti-Murhesa and Katana are agriculture, livestock farming, fishing and petty trading, with 70% of the population living below the poverty line.[26]

Study design and population

Our observational study focused on the follow-up of a group of adults who had SAM as a child living in Eastern DRC. The participants in our study were drawn from a cohort of patients formerly admitted for SAM at Lwiro Paediatric Hospital (LPH) between 1988 and 2007 and living in the HZs of Katana and Miti-Murhesa in 2018.[19]

During the follow-up of these participants, who became adults 11–30 years after nutritional rehabilitation, 524 subjects from the initial cohort who were still living in the

Miti-Murhesa and Katana HZs were interviewed.[19] Individuals with a history of malnutrition as a child (SAM+) were selected from the cohort, of whom 257 agreed to take part in the survey, making up the study population (exposed group). For each exposed subject, an unexposed community subject (SAM−) was randomly selected for comparison. An unexposed comparison participant was defined as a person who had no hospital history of SAM (information obtained from close relatives with a match in the LPH database), was of the same sex, was living in the same community and was ≤24 months older or younger than the exposed participant. We selected community unexposed participants randomly by spinning a bottle at the exposed adult's home and enquiring door to door, starting from the nearest house to where the bottle pointed until someone meeting the criteria was found.[19] Initially, we wanted to have one non-exposed person for each exposed person. However, unexposed participants were more difficult to recruit than exposed participants because most feared being associated with SAM in childhood, which is stigmatising in the society, and their recruitment was limited to the number of eligible adults in the community. As a result, we recruited 187 community participants, giving a ratio of unexposed to exposed participants of 0.73:1.

Power calculation

Based on the high dependency rate of 9.2% observed in the general population in a recent regional study using WHODAS,[25] and assuming a significance level of 5% and a two-sided test, our study with 257 exposed and 187 non-exposed individuals would have a power of 80% to detect a difference of at least 9.4%.

Variables, instruments and measurements

The main outcome of this study is the WHODAS summary score, which measures an individual's health status. The WHODAS score ranges from 0 to 48 (each of the 12 items is rated from 0 to 4), measuring the cognitive, functional and social performance of the participants; the lower the score, the better the health status.

WHODAS is a 12-item standardised WHO questionnaire with good psychometric properties[27 28] and has been adapted to several cultures and validated in several countries,[29] including among children in the rural areas of LMICs.[30] In a recent study, it was shown that WHODAS can be used to measure the health status of populations in rural and semiurban areas of South Kivu.[25]

We converted this score into a new score ranging from 0 to 100 for easy comparison and interpretation.[20] Even if there is no agreed cut-point for identifying persons with significant disability, according to Andrews *et al*[21] a person with a WHODAS score above 10 out of 48 (21 out of 100 in our study) is likely to have clinically significant disability. The other levels of disability according to the score achieved were 0 (presumed to be without disability), 2–9 (with mild disability) and 10–20 (with moderate disability).[20]

We did not perform any factor analysis in our study to transform the WHODAS items. However, to better understand which components of daily life of people with a history of SAM during childhood are most impaired compared with people without a history of SAM, we used the results of the exploratory principal components analysis of Andrews *et al* on the general population in Australia.[21] The 12 items of WHODAS were condensed into six domains of disability (assisting and completing daily tasks, acquiring and using information, moving and handling objects, taking care of self, interacting with others and participating in society). Each domain was scored out of 8 because it represented the sum of two WHODAS items (where each item is normally scored out of 4).

Sociocultural and demographic characteristics were analysed as explanatory variables. Socioeconomic status (SES) was established on the basis of an empirical score taking into account the participant's education, profession and living conditions, deduced from the sum of material possessions (categorised into three groups with the following thresholds: 0–3=little, 4–6=average and 7–9=a lot), land ownership (yes/no) and type of dwelling where the participant lives (in three categories: precarious, average and good).[8] This empirical score had already been used in our context to estimate the SES of subjects in the province of South Kivu.[18] The type of occupation was based on ISCO 88 (International Standard Classification of Occupation), the French-language version of Iadapted for the European Union.[24] For the sake of applicability to our context, the first three occupational classes were merged to form class 1 (managerial staff). Then, the fourth and fifth classes became, respectively, class 2 (administrative and office worker) and class 3 (farmer, fisherman and market vendor). Finally, the sixth and seventh classes were merged into class 4 (unskilled workers). Participants with no occupation were classified as class 4.

On the basis of these elements, the participants were divided into three SES categories.[18] We defined a *participant with a low SES* as any subject living in poor conditions (precarious housing, possessing few material goods and with or without land ownership), regardless of occupation and level of education. A *participant with an average SES* was defined as anyone who works in a class 3 or 4 occupation, regardless of level of education, and with good living conditions (good housing, possessing a lot of material goods and with land possession), or a *participant* living in average living conditions (average type of housing, average quantity of goods and with land possession) who has completed at most secondary education and works in a type 2, 3 or 4 occupation.[18] Finally, a *participant with a high SES* was defined as anyone with a class 1 or 2 occupation, regardless of level of education, and with good living conditions (good housing, many possessions and with land), or a subject living in average conditions, working on a type 1 occupation and has attained university-level education.[18]

The variable 'membership of a local savings association' includes people who belonged to any community development association.

Data collection

Data collection took place between August 2021 and December 2021 (5 months) and was carried out by 20 trained community health workers (CHWs) and 2 supervisors, and facilitated by neighbourhood chiefs, head nurses and community relays. The CHWs were the same as those who participated in the identification of the participants (SAM+) during the reconstitution of the cohort.[18]

The basic structured questionnaire in French (sociodemographic data and WHODAS) was translated into Swahili (the national language in Eastern DRC) according to a rigorous translation protocol to ensure intercultural and conceptual equivalence. A French-speaking translator from the language school of the Université Catholique de Bukavu and whose first language is Swahili carried out the translation. A bilingual panel composed of the principal researcher, key health professionals working in the field in the two zones covered by our study and community health officers examined the translated version in order to correct any intercultural issues in terms of incomprehensibility or lack of clarity. The resulting document was then translated into French by an independent bilingual reviser. Once translated, a native French speaker compared this French back translation with the original French version to confirm equivalence. Before proceeding with the study, the questionnaire was revised and modified following tests in the field, with a pilot study conducted on a subgroup of 30 people from the region (15 with a French questionnaire and 15 with a Swahili questionnaire), selected from within the community. The interviews lasted between 30 and 50 min.[20]

Data analysis

Data were encoded in Epi Info V.7 before being exported to Excel for cleaning and were analysed using SPSS V.26. Qualitative variables were summarised as frequencies and percentages, while median with minimum and maximum was used to summarise quantitative variables. We used the Box-Cox transformation to normalise our dependent variable, WHODAS score. WHODAS score was described with a median along with the 25th and 75th percentiles (P25–P75), and the Mann-Whitney test was used for comparison between the subgroups. The tests and methods used to analyse WHODAS score were Pearson's χ^2, and when it was not applicable the Fisher's exact test was used. In order to identify potential confounding factors for the association between WHODAS score and SAM, variables significantly associated with SAM and WHODAS were introduced in a multivariable logistic regression model. Given the correlations between the socioeconomic variables, they were introduced one by one to the model. Interactions between SAM and socioeconomic variables were also tested.

Patient and public involvement

Patients and the public were not involved in the design, conduct or reporting of our research.

Ethical considerations

Respondents provided signed informed consent for participation in the study, either by written signature or by fingerprints, depending on literacy. For children <18 years of age, consent was obtained from the children's parents or guardians.

RESULTS

General characteristics of the study population (SAM+ vs SAM– participants)

Table 1 summarises the sociodemographic and economic characteristics of the study population. The median age of the participants in both groups was 20 years. SAM+ participants had lower levels of education and SES, had worse employment situations and also made less use of social networks. These differences were statistically significant. There were no statistically significant differences in terms of religion, participation in local associations or access to radio information.

Comparison of the overall WHODAS score in the two groups (SAM+ and SAM– participants)

The median (P25–P75) WHODAS score in SAM+ participants (n=257) was 25.0 (14.6–33.3), whereas in SAM– participants (n=187) it was 8.3 (4.2–14.6) (p<0.001) (figure 1), with a difference in median of 16.7 (95% CI 14.3 to 19.1).

Areas of daily life most affected in SAM+ participants compared with SAM– participants

Table 2 shows the six disability domains in the two groups. Compared with the median of the different disability domains among SAM– participants, SAM+ participants had poorer health status, with a statistically significant difference in all domains, except for individual self-care, for which no statistically significant difference was observed.

Analysis of the categorised WHODAS score in the different subgroups

In terms of degree of dependency, 63% of SAM+ participants had a high level of dependency, 19.5% a medium level of dependency and 17.5% a minor level of dependency, following an almost inverse dynamic to that of SAM– participants (54.6% had a minor level of dependency, 28.9% had a medium level of dependency and 16.6% had a high level of dependency). With regard to other sociodemographic parameters, we observed that a large proportion of participants with low SES, those with unskilled jobs, those not using social networks and those with a low level of education had a higher level of dependency than the other subgroups of the same categories, and this was statistically significant (table 3).

Table 1 Sociodemographic characteristics of the case (SAM+) and control (SAM–) groups

Variables	SAM+	SAM–	P value*
Age	20 (16–37)†	20 (16–35)†	0.820‡
Sex			0.963*
Male	119 (46.3)	87 (46.5)	
Female	138 (53.7)	100 (53.5)	
Marital status			0.006*
Not in union	137 (53.3)	124 (66.3)	
In union	120 (46.7)	63 (33.7)	
Religion			0.899*
Catholic	108 (43.0)	76 (41.1)	
Protestant	136 (54.2)	103 (55.7)	
Other	7 (2.8)	6 (3.2)	
Ethnicity			0.141*
Shi and Havu	247 (99.2)	176 (97.8)	
Rega	2 (0.8)	1 (0.6)	
Other	0 (0.0)	3 (1.7)	
Level of education			0.002*
No	68 (26.9)	28 (15.1)	
Primary	96 (37.9)	66 (35.5)	
Secondary	87 (34.4)	85 (45.7)	
University	2 (0.8)	7 (3.8)	
Socioeconomic status			0.002*
High	7 (2.9)	13 (7.9)	
Medium	79 (33.2)	74 (44.8)	
Low	152 (63.9)	78 (47.3)	
Professional category			0.043*
Management agent	8 (3.3)	14 (8.4)	
Office agent	1 (0.4)	2 (1.2)	
Farmer, fisherman and salesman	159 (66.0)	107 (64.5)	
Unskilled worker	73 (30.3)	43 (25.9)	
Membership of a local association			0.460*
No	203 (79.9)	144 (77.0)	
Yes	51 (20.1)	43 (23.0)	
Access to radio information			0.075*
No	148 (58.3)	93 (49.7)	
Yes	106 (41.7)	94 (50.3)	
Use of social networks			0.010*
No	213 (85.5)	137 (75.7)	
Yes	36 (14.5)	44 (24.3)	

*P value of the Pearson's χ^2 test or the Fisher's exact test.
†Median (minimum–maximum).
‡P value of the Mann-Whitney test.
SAM, severe acute malnutrition.

Factors associated with poor health (high WHODAS score)

In the multivariable logistic regression model, occupation, SES and use of social networks, introduced separately in addition to SAM, remained significant but had no confounding effect on the association between SAM and WHODAS score. Interactions between SAM and the socioeconomic variables (gender, education, occupation and use of social network) were all non-significant (table 4).

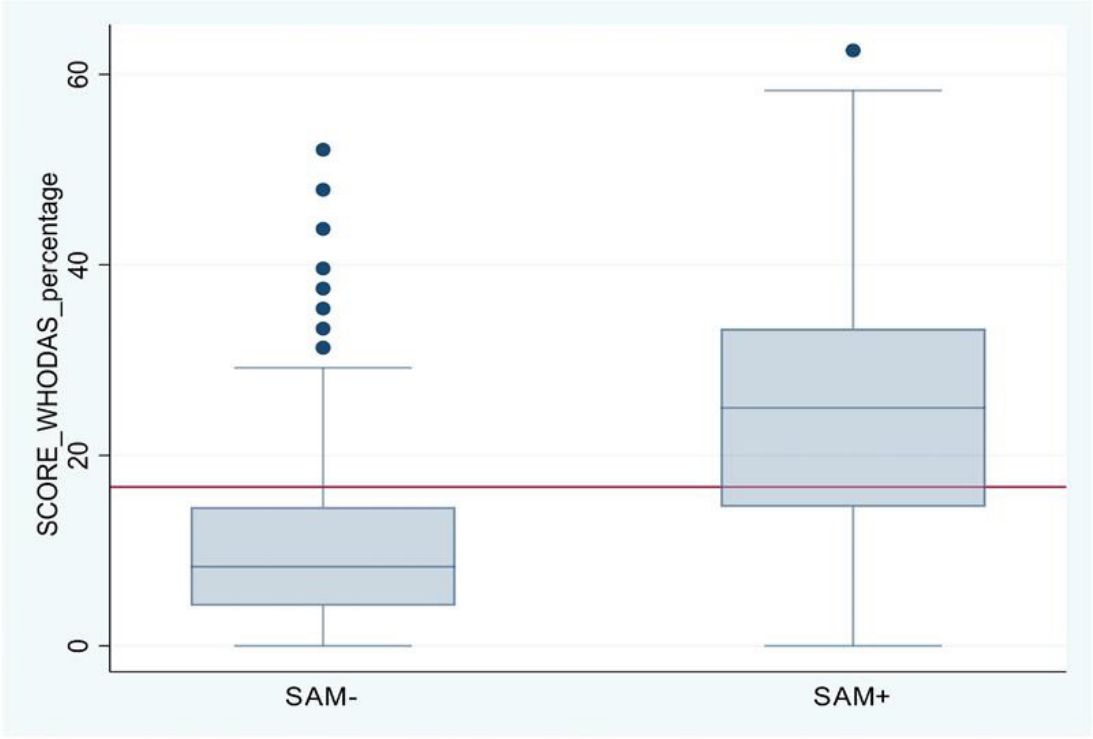

Figure 1 Comparison of the overall WHODAS score in the two groups (boxplot). WHODAS, WHO Disability Assessment Schedule.

DISCUSSION

The aim of this study was to explore the long-term associations of SAM in childhood with health status in adulthood using the WHODAS 2.0 tool and identify the factors associated with poor health status. Our study found that being SAM+ was predictive of a higher WHODAS score, indicating an overall low health status of adults with a history of SAM compared with the general population.

Our study is the first to investigate the health status of adults with a history of SAM living in areas affected by complex crises linked both to armed conflict and food insecurity in South Kivu. This is all the more relevant to public health policy as, in most cases, the state of health of the population is assessed through indicators of disease management or health programmes. The use of WHODAS allows for assessment of the state of health of the population in general, and of those with a history of SAM in particular, from a different perspective in terms of development capacity. It thus provides policymakers with more integrative data on the real health status of a population, particularly in regions with chronic crises.

Our results show that the overall WHODAS score of SAM+ participants was significantly worse than that of SAM− participants, indicating that SAM+ participants clearly had a poorer state of health. We also observed that SAM during childhood was associated with deleterious long-term effects on the individual, exposing survivors to lower SES, lower academic achievement and poorer work situation. In terms of health-related disabilities, despite being more dependent than the general population, there was no difference in terms of individual self-care, as compared with SAM− participants.

Table 2 Comparison of WHODAS score items between SAM+ and SAM− participants

	SAM+ (n=257) Median (P25–P75)	SAM- (n=187) Median (P25–P75)*	P value*
Daily tasks (household)	25.0 (12.5–50.0)	0.0 (0.0–12.5)	<0.001
Cognitive	25.0 (0.0–37.5)	0.0 (0.0–12.5)	<0.001
Mobility	37.5 (12.5–62.5)	12.5 (0.0–25.0)	<0.001
Self-care	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.139
Social interaction	25.0 (0.0–37.5)	0.0 (0.0–12.5)	<0.001
Participation in the society	25.0 (12.5–37.5)	12.5 (0.0–25.0)	<0.001

*P value of the Mann-Whitney test.
P25, 25th percentile; P75, 75th percentile; SAM, severe acute malnutrition; WHODAS, WHO Disability Assessment Schedule.

Table 3 Analysis of the categorised WHODAS score in the different subgroups

	None n (%)	Mild n (%)	High n (%)	P
SAM				
SAM+	45 (17.5)	50 (19.5)	162 (63.0)	<0.001
SAM-	102 (54.6)	54 (28.9)	31 (16.6)	
Age (years)				
<20	54 (37.0)	31 (21.2)	61 (41.8)	0.825
20–24	63 (33.3)	45 (23.8)	81 (42.9)	
25–29	20 (28.6)	17 (24.3)	33 (47.1)	
30	10 (25.6)	11 (28.2)	18 (46.2)	
Sex				
Male	73 (35.4)	46 (22.3)	87 (42.2)	0.619
Female	74 (31.1)	58 (24.3)	106 (44.5)	
Marital status				
Not in union	88 (33.7)	61 (23.3)	112 (42.9)	0.943
In union	59 (32.2)	43 (23.5)	81 (44.3)	
Religion				
Catholic	57 (31.0)	41 (22.3)	86 (46.7)	0.675*
Protestant	84 (35.2)	56 (23.4)	99 (41.4)	
Other	5 (38.5)	4 (30.8)	4 (30.8)	
Education Level				
No	24 (25.0)	18 (18.8)	54 (56.3)	0.036
Primary	52 (32.1)	40 (24.7)	70 (43.2)	
Higher	69 (38.1)	46 (25.4)	66 (36.5)	
Occupation				
Management/office agent	14 (56.0)	9 (36.0)	2 (8.0)	0.001
Farmer, fisherman and salesman	86 (32.3)	62 (23.3)	118 (44.4)	
Other	28 (24.1)	24 (20.7)	64 (55.2)	
ocioeconomic status				
High	11 (55.0)	7 (35.0)	2 (10.0)	0.004*
Medium	51 (33.3)	38 (24.8)	64 (41.8)	
Low	64 (27.8)	50 (21.7)	116 (50.4)	
Member of a local association				
No	111 (32.0)	76 (21.9)	160 (46.1)	0.064
Yes	35 (37.2)	28 (29.8)	31 (33.0)	
Access to radio information				
No	72 (29.9)	56 (23.2)	113 (47.0)	0.195
Yes	74 (37.0)	48 (24.0)	78 (39.0)	
Use of social networks				
No	108 (30.9)	78 (22.3)	164 (46.9)	0.01
Yes	36 (45.0)	21 (26.3)	23 (28.8)	

*Fisher's exact.
†Tests: χ^2 test or Fisher's exact test.
SAM, severe acute malnutrition; WHODAS, WHO Disability Assessment Schedule.

Table 4 Factors associated with poor health (high dependency vs none or mild)

	N	% High dependency	High dependency / none or mild OR (95% CI)	P
SAM				
SAM+	257	63	8.6 (5.4 to 13.6)	0.002
SAM -	187	16.6	Reference	
Education Level				
No	96	56.3	2.2 (1.4 to 3.7)	0.002*
Primary	162	43.2	1.3 (0.9 to 2.0)	
Higher	181	36.5	Reference	
Occupation				
Management/office agent	25	8	Reference	<0.001*
Farmer, fisherman and salesman	266	44.4	9.2 (2.1 to 39.7)	
Other	116	55.2	14.2 (3.2 to 62.8)	
Socioeconomic status				
High	20	10	Reference	0.001*
Medium	153	41.8	6.5 (1.5 to 28.9)	
Low	230	50.4	9.2 (2.1 to 40.4)	
Use of social networks				
No	350	46.9	2.2 (1.3 to 3.7)	0.003
Yes	80	28.8	Reference	

Tests: χ^2 or χ^2 for trend.
*χ^2 for trend.
SAM, severe acute malnutrition.

Our results are in line with the findings of several studies that have associated SAM in childhood with a subsequent reduction in human capital as regards educational, socioeconomic and professional levels.[6 9 31] One potential contributing factor could be that childhood malnutrition had irreversible deleterious effects on brain development,[32] as a result of a decrease in myelin, an increase in neuronal mitochondria, a decrease in cortical dendrites in the neural spines and a lower ratio of granule cells to Purkinje cells in the cerebellum, altering motor and cognitive development,[32] thus substantially impacting later schooling. As professional qualifications are a function of the schooling level, if the latter were disrupted by malnutrition, it would be less likely for survivors of malnutrition to access more profitable work positions, leading to more precarious living conditions and ultimately to higher risk of poverty, which has also been linked to lower productivity.[18]

The median WHODAS score obtained for the entire population was 8. This median score is almost identical to that of people with good cognitive performance in Tanzania[33] and that found in a study comparing health status in different HZs of South Kivu.[20]

SAM+ participants in the present study had a median WHODAS score of 25, much higher than the SAM– participants, thus classifying them in the category of significant deficit or in a group of people with high dependency.[21 25] This poor state of health affected five of the six areas of disability, with the exception of individual self-care. This poor health status confirms the multiple sequelae of SAM in childhood, affecting the cognitive, physical and socioeconomic domains.[6 34 35] With regard to cognition, its deterioration in adulthood is thought to result from deleterious cerebral biochemical changes that reduce cognitive capacity during childhood and later in adult life.[9] The emergence of chronic comorbidities,[25] which are part of the consequences of childhood malnutrition,[18 36 37] as well as low self-esteem,[9] as a result of stigma attached to malnutrition, could underlie the present state of health of SAM+ participants, characterised by combined deficiencies in mobility, performance of daily tasks, participation in society and social interaction, social and personal resources, and physical capacity, all of which form an integral part of the definition of health.[25]

With regard to the degree of dependence, 63% of subjects exposed to infantile SAM had a high level of dependence, 19.5% medium level and 17.5% minor level, a distribution that follows an almost inverse gradient to that of unexposed individuals and of the general population, of whom only 10% had a high level of dependence.[21 25] This practically reflects the serious consequences of childhood malnutrition, leading to a reduction in human capital at the various levels mentioned above.[6 18 34 35]

The deleterious cognitive, physical and social consequences of childhood malnutrition[6 18 25 34 35 38 39] have a negative impact on health status, and our study shows that exposure to malnutrition during childhood increases the odds of poor health status by a factor of 8 compared with SAM− individuals. In the multiple linear regression model, being SAM+ was predictive of a higher WS score. This may be due to the fact that the deleterious cognitive effects of childhood malnutrition have a negative impact on the learning process at school[6 40] and predispose survivors to lower professional qualifications, with subsequent access to lower-paying jobs. This leads to precarious socioeconomic living conditions,[34 41] with lower household spending capacity and high risk of insecurity/poverty, which in turn have a negative impact on all aspects of a person's life, including the state of health. Furthermore, most of these SAM survivors received different treatment during their nutritional rehabilitation (1988-2007). The current treatment programmes used in modern community management of acute malnutrition (CMAM) programmes were only introduced in 1997 at LPH.[19] Indeed, nutritional therapy has changed over the years, with three distinct periods. During the first period (1987–1994), treatment was based on MASOSO gruel, which is a blend of corn, soy and sorghum. In the second period (1994–1996), a key feature was the administration of locally produced high-energy milk (HEM), which was a mixture of milk, oil and sugar and had an energy density close to 90 kcal/L. During the third period (August 1996–December 2007), HEM was replaced by the therapeutic milk F-75 (in the first phase of treatment) and F-100 (in the second phase),[42] a difference that could have influenced the outcomes in adulthood. Indeed, modern formulations of ready-to-use therapeutic food (RUTF) target cognitive recovery/development with optimised polyunsaturated fatty acids that could well improve the outcomes of adult survivors of SAM, unlike those previously administered. This is consistent with the findings of the studies conducted in high and middle-income countries (HMICs), which observed that undernutrition in childhood was not associated with disabilities in carrying out daily tasks (household and professional) in adulthood.[43 44] This is due to the benefits of nutritional rehabilitation and catch-up growth after treatment, promoting the social reintegration of malnutrition survivors by making them autonomous in daily life, despite their cognitive disabilities. Indeed, our subjects spent their childhood in precarious nutritional conditions before experiencing one or more episodes of SAM, and then continued to live in an unfavourable environment in terms of food quality and security, without nutrition transition.[18] The deleterious effects may have been expressed to a greater degree in the exposed than in the non-exposed individual, even if they live in the same poor environment.

The strengths of this study include the matched controls, its prospective nature and the use of a standardised tool to assess the outcomes. However, the study had some limitations. First, our greatest limitation is survivor bias. In our study, only 257 out of 1981 baseline subjects were included in the cohort. Consequently, survivor bias could have led to conservative results in our own cohort, that is, children with SAM with the most severe disability could have died, reducing the contrast between SAM+ and SAM− adults who survived. Studies have identified a high risk of mortality among children with SAM with early onset of disabilities; for example, four in five children with cerebral palsy had died after 7 years.[32] Second, overall health is the result of many other individual, sociocultural and environmental parameters that are difficult to assess. Nevertheless, our study shows that having malnutrition as a child in rural South Kivu is an important factor contributing to poor health status of the adult population. Third, this study was observational in design and calls for caution in terms of attributing causality. Apart from exposure to SAM, other factors may have modulated the various parameters studied, and some of these factors may have occurred prior to the SAM episode, particularly during pregnancy, early childhood or stunting during childhood. They may also be linked to other physical and social environment variables in which our subjects lived before and after discharge from hospital (household status when the adult was a child with SAM). Fourth, we did not have demographic information on infancy, including family history, mental health, gestational age, birth weight and height, rate of growth in the first 2 years of life and episodes of infectious diseases (particularly diarrhoea), as well as socioeconomic data concerning their mothers (level of education and age at birth). These items could be potential confounding factors because they are linked to both malnutrition and negative long-term effects on education and cognition.

CONCLUSION

Our results suggest that exposure to SAM during childhood is associated with deleterious effects on general health in adulthood in Eastern DRC. As regards health-related disabilities, despite being more dependent than the general population, there was no difference in self-management between subjects with a history of malnutrition and those not exposed to childhood malnutrition. Health researchers and decision-makers should envisage allocating more resources to studying the long-term effects of SAM, since preventing its occurrence represents a preventive health measure for good adult health and prosperous future for at-risk populations, especially in the context of chronic armed conflicts such as those in DRC and taking into account the well-being of the individual as a whole.

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ORCID iDs
Samuel Makali http://orcid.org/0000-0003-3538-1715
Pacifique Mwene-Batu http://orcid.org/0000-0003-0413-2732

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