ORIGINAL ARTICLE

The role of exclusive breastfeeding and water sources in the reduction of stunting: Mediation and moderation analysis of cross-sectional data among Beninese children aged 6 months

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Abstract. *Background:* Stunting is a public health issue in many low and middle income countries. The role played by exclusive breastfeeding practice (EBF) and water source (WS) used by the mothers in stunting reduction needs to be more clarified. *Objective*: To test whether EBF and WS are moderators or mediators of participation in Nutrition at Centre (N@C) project activities effect on child stunting reduction. *Methods*: We used cross-sectional data on 213 mothers and their 6 months' age children from 40 villages in Southern Benin. Scores of participation in N@C activities (SPA) were estimated by counting the activities in which the mothers have participated during the last six months. Association between prevalence of stunting (length-for-age z-score < - 2) and SPA was investigat-ed binary and multinomial logistic regression. Then, EBF and WS were included in the models to check whether they were mediators or moderators. *Results*: In our sample, 16% of children were stunted. High SPA of mothers was likely associated with low stunting prevalence (OR=0.92; 95% IC: 0.87-0.98). We did not have evidence to claim that neither EBF nor WS were a mediator of the effect of SPA on stunting reduction, but they were moderators. While the score of participation increased and the mothers didn't practice EBF, the stunting prevalence increased slightly from 21.4% to 26.8%. Moreover, the score of participation increased and WS is drilling system or covered well or tap, the stunting prevalence decreased by 15.6%, 26.9%, and 45.4%, respectively. *Conclusions*: EBF and WS have been the moderators of SPA effect on children stunting prevalence at 6 months of age. Effective practice of EBF and the use of appropriate WS by the mothers are needed to have a large effect of participation in the nutrition community projects on the reduction of stunting.

Key words: exclusive breastfeeding, stunting, water-source, structural equations models

Introduction

Despite the progress made to date, many low and middle income countries including Benin, continue to fight against stunting. Since 1996, the prevalence of stunting among under 5years Beninese children remained high and more than 30% (1). The consequenc-es of stunting include an increase of infant and child mortality and morbidity; increase of overweight risk, obesity and non-communicable diseases later in life, low psychomotor development and loss of economic potential (2). Benin has adhered to Scaling Up Nutrition movement and has adopted national policies to promote nutrition and reduce stunting. Ever since,

some international and national organizations working in nutrition and food sectors, have initiated many projects. For instance, CARE International Benin/Togo has implemented Nutrition at the Center (N@C) project in two communes of Southern Benin. The main target of the project was social and behavior change of key household practices at the community level and delivery of basic public services. N@C strategy was based on nutritional education with Village Loan and Savings Associations (VLSA) and would have shown many successes in their community (3). Thus, the mechanism of N@C actions should be documented before being spread to others communes. The level of participation in activities whatever the zone (intervention or control) could be important to appreciate the effect of the activity types N@C. Even if mothers in the control zone did not participate in N@C project, they could be exposed to the usual activities developed by health fieldworkers from the local health systems.

Indeed, the activities that N@C had implemented were based on interventions that have been proven to reduce stunting in early childhood, if implemented to scale up (1). However, in the recent literature, many of the interventions like promotion of exclusive breastfeeding (EBF) from 0 to 6 months of age; promotion of diverse complementary feeding (CF) practices, with or without provision of food supplements and interventions targeting improvements in water, sanitation, and hand washing, have shown a low effect depending on the context, countries, and types of Studies (4,5).

Moreover, there is a growing interest in how water, sanitation, and hygiene (WASH) interventions might support strategies to reduce stunting in high-burden settings (6). Especially, water source has been associated with stunting prevalence (7). During the first months of a child, even if mothers adhere to EBF practices but do not adopt good practices of hygiene, their children will still be exposed to diarrhea and infections (8). However, the evidences of WASH intervention in the reduction of stunting were contradictory (9, 10, 11). The role of water sources (WS) in the stunting reduction program needs to be documented.

This study hypothesized that the stunting prevalence at 6 months in the group of mothers that have participed in N@C activities would be lower than the one of the mothers with low level of participation.

Thus, we have tested if participation in activities over the last six months was associated with better EBF practice and use of safe drinking WS by the mothers. Then, we checked whether EBF and WS could be moderators or mediators of the effect that the activities led by N@C might have on stunting reduction at 6 months.

Materials and Methods

Brief description of the activities N@C

From 2014 to 2017, the activities of N@C have been essentially based on Social and Behavior Change Communication (SBCC) related to maternal, infant and young child nutrition and health (MIYCN), WASH, food security, and women's empowerment (3). The types of activities are summarized in **Table 1.**

Data used.

This analysis uses the cross-sectional data of the add-on study post evaluation conducted from June 2017 to March 2018 in the context of the interregional project INT6058 of the International Atomic Energy Agency (2016-2019). Isotope methods were also used to appreciate the project effect on the evolution of child body composition from 6 to 12 months of age (12). Here, we analyzed to understand why and/or how N@C activities could reduce the prevalence of stunting among children aged 6 months. Ethical approval was obtained from Benin National Ethics Committee for Health Research of Ministry of Health (CR n°05 on 26/01/2017 and N°15/MS/DC/SGM/DRFMT/CENRS/SA on 07/04/2017).

Sampling and recruitment of participants.

The intervention zone was Dangbo and the control, Tori-Bossito. The later has been chosen due to its similar economic and food insecurity situation compared to Dangbo according to Benin National Institute of Statistics and Economic Analysis (13). The 6 months' age children whose parents accepted to participate in the study, were included. Meanwhile, we did not include i) sick children, ii) parents who refused to participate in, iii) children with severe malnutrition or with natural growth issues.

Table 1. N@C activities summarized by sector

1. Nutrition-specific activities
Infant & Young Child Feeding Practices (IYCF)
1.1 Culinary demonstration (food group, consistency, quantity)
1.2 Food cards game.
1.3 Spots radio, community durbars (*Atchakpodji)*, broadcasted messages by local radio ;
1.4 Communication about exclusive breastfeeding, Complementary Feeding, consumption of animal product, taken of iron tablets and feeding during pregnancy
1.5 Home visits
Infant and Matenal Health
1.6 Advanced Strategy for the growth promotion of healthy infants ;
1.7 Spots radio, community durbars, broadcasted messages by local radio ;
1.8 Communication about pre and post-partum communication, malaria, diarrhea infection, and Vaccinations ;
1.9 Community videos on fœtus development
1.10 Home Visits
2. Nutrition-sensible activities
Water, Sanitation and hygiene (WASH)
2.1 Salubrity session
2.2 Spots radio, community durbars, radio channel;
2.3 Communication on the storage and transportation of drinkable water, and importance of body and home cleanness;
2.4 Community movies about the Relationship between lack sure water and malnutrition
2.5 Home Visits
Food Security
2.6 Promotion of small and community gardens through training and technical empowerment ;

Sample size was estimated by Fleiss's formula (14). Before the implementation of N@C project in Dangbo, the prevalence of stunting was 33.8% (15). Assuming sixteen-point difference of stunting prevalence between both zone intervention and control at the end project (16), for 80% power and 5% of precision, 213 children have been included in this analysis with 109 in the intervention zone.

Questionnaires. Questionnaires were administered to children's mothers with a mobile survey system using the Open Data Kit (ODK) (17). They were related to socio-economic, food insecurity situation, and water, sanitation and hygiene practices within households, feeding practices including early initiation of breastfeeding and exclusive breastfeeding, and the types of activities that the mothers have participated in during the last 6 months.

Anthropometric measures.

Children's anthropometric measures (weight and height) have been taken with a baby scale (SECA 354, precision: 10g, range: 20 Kg) and a height gauge (ShorrBoard©, precision: 1 mm). Each observation has been measured three times. We computed the coefficient of variation (CV) iteratively of two observations (weights or heights) from the three measurements and we compared them. We kept the means of two meas- urements which have the smallest CV (18).

Variables descriptions
- Length-for-age Z-score (LAZ) was computed by WHO Anthro software, and LAZ<-2 was considered as stunted (18).
- Score (SPA): It is a discrete variable which gives the number of participated activities over the types of N@C projects presented in Table 1.
- EBF: It is a categorical variable (Yes or No) which stipulates if a child is exclusively breastfed or not.
- Stunting: It is a categorical variable (Yes or No) which stipulates if a child is stunted or not.
- Zone: It is a categorical variable (intervention or control zone) which shows the community in which each observation has been selected.
- WS : It is a categorical variable that gives the household water source ("Drilling", "Covered well (CW)", "Non covered well and Stream" (UW),"Tap").

Statistical analysis

Brief theory of path analysis

1. Mediation analysis: Mediation model is a way to understand how or why a variable X is related to another variable Y (19). It hypothesized that a mediator M must be intermediate in the relation between X and Y (Figure 1 A).

First model $\quad\quad$ $\text{logit}[P(Y = \text{"Modality of interest"})] = \alpha_1 + \beta_1 X \quad (1)$

Second model $\quad$ $\text{logit}[P(M = \text{"Modality of interest"})] = \alpha_2 + \beta_2 X \quad (2)$

Third model $\quad\quad$ $\text{logit}[P(Y = \text{"Modality of interest"})] = \alpha_3 + \beta_3 X + \gamma_3 M \quad (3)$

Where α_i (i=1:3) is the intercept, β_i (i=1:3) is the re-gression coefficient related to X, γ_3 is the regression coefficient related to M. Logit is the link function such that:

$$logit[A] = log\left[\frac{P(A=a)}{1-P(A=a)}\right]. \qquad (4)$$

Firstly, we checked if β_1 was significant. If it was not, we could not continue the mediation analysis (20). Meanwhile, other authors said that we can still do the mediation analysis with a good literature about the re-lationship among the used variables (21). Moreover, to conclude about the mediation, the coefficients and β_2 and γ_3 should be significant too. About the ideal mediation, β_3 should not be significant. In case it is, we have a partial mediation and this means that the influence of X on Y through M is not completely in M. Besides, to test the significance of the indirect effect, we computed the Sobel's test (22). In addition, we have implemented Monte Carlo method to test again the significance of the mediated effect ($\beta_2\gamma_3$).

2. Moderator analysis: A moderator is a third variable which is able to reverse, increase, or decrease the effect of the predictor on the outcome variable. By the way, it helps to know when that effect happens (Figure 1 B).

$$logit[P(Y = \text{"Modality of interest"})] = \alpha_4 + \beta_4 X + \gamma_4 M' + \delta_4 X M' \qquad (5)$$

When δ_4 is significant, we can think of a moderated effect. About the test of the significance of that moderation, we need to prove that, when the moderator varies, the effect of X on Y changes too.

Estimate Process. The computation of each coefficient was done through the Maximum Likelihood Estimate Process. Be the general model written as follows:

$$logit[P(Y = \text{"Modality of interest"})] = \sum_{k=0}^{K} x_{ik}\beta_k \qquad (6)$$

For i=1, 2, …, n; K: the number of independent variables. To estimate β_k, we used the Maximum Likelihood Estimation. The likelihood is as follows:

$$L(\beta/y) = \prod_{i=1}^{n} \left(\frac{p_i}{1-p_i}\right)^{y_i} (1-p_i) \qquad (7)$$

with

$$p_i = \frac{e^{\sum_{k=0}^{K} x_{ik}\beta_k}}{1+e^{\sum_{k=0}^{K} x_{ik}\beta_k}}$$

With a negative second derivative of eq (7), We can notice that, when we have this equation, we cannot easily have the analytical expressions of ; thus we implemented Newton-Raphson algorithm on the first derivative of eq (7) to get estimates of the parameters β_k.

Process of statistical analysis.
We observed statistics of each of the variables through descriptive statistics. We computed proportions for qualitative variables' modalities and mean, median, and standard deviation for quantitative variables. The regressions have been implemented for checking whether EBF and Water Sources are mediator or moderator. Especially when a variable is suspected to be a mediator, Sobel's test and Monte Carlo have been computed to check the significance of that indirect effect. Moreover, when a regression seems not to fit the data, an additional transformation has been done. Especially for the regressions with high Variance Inflation Factor (VIF), we centered the quantitative variable and computed again the model. For
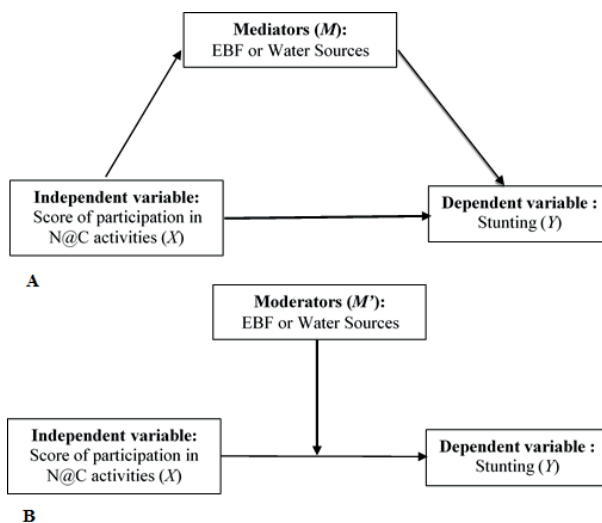
Figure 1. Representation of model analysis, A for mediation model and B for moderation model
A: Mediation model
M: EBF or Water source; *X*: Score of participation in N@C activities (SPA), *Y*: Prevalence of Stunting
B; Moderation model
M': EBF or Water source; *X*: Score of participation in N@C activities (SPA), *Y*: Prevalence of Stunting

the modality "uncovered well", for example, we have suspected water source to be a mediator. Therefore, we have tested the significance of the indirect effect with Monte-Carlo simulation and Sobel's test and used their confidence intervals.

Robustness of model.

For the robustness of mediation analysis, we implemented a simulation of 100.000 trials to check the significance of potential mediators. About the moderation analysis, we implemented the analysis of deviance to get the variable which really helped in the decrease of the deviance in the model; and the VIF of each coefficient. The plots were drawn from the predicted prevalence of stunting in function of the score of participation. The dummy variables have enabled to get the predicted prevalence of stunting.

Results

Description of the sample size by studied variables.

We analyzed the data of 213 couples mother-children aged of 6 months and found that 65% of the mothers declared to exclusively breastfeed their children. Moreover, respectively, 40%, 34%, 18%, and 8% of the mothers got water from Drilling systems, Tap, Covered wells, and Uncovered wells and streams.

Globally, 16% of the children were stunted. The prevalence of stunting in the intervention zone (7.34%) was significantly (P=0.0003) smaller than the one in the non-intervention zone (25%).

Score of participation in activities (SPA) by zone and by stunting.

SPA median was 15 activities (25ie -75ie: 8-21) in the intervention zone and was 4 activities (25ie -75ie: 1-6) in non-intervention zone. In the non-intervention zone, almost 88% of mothers have participated in less than 10 activities; this proportion was 32% in the intervention zone. For a SPA less than or equal to 10 activities, 21% of children were stunted, whereas for a SPA greater than 10 activities, only 9% of children were stunted, with a significant difference (P=0.019; Figure 2).

Effect of SPA on stunting prevalence at 6 months.

The score of participation in N@C activities had a significant influence (P=0.009) on 6 months stunting prevalence. High SPA of mothers were likely associated with low prevalence of stunting in our sample (OR: 0.92; 95% IC: 0.87-0.98; Model 1 in Table 2).

Exclusive Breastfeeding as mediator

The score of participation in the activities might have a significant influence (P < 0.001) on the EBF rate. We noticed that mothers with higher SPA were likely to practice EBF (OR: 1.15; 95% IC: 1.09 -1.21; Model 2 in Table 2).

In model 3 (Table 2), we observed that the EBF coefficient was not significant (P= 0.41); there is no evidence to affirm that EBF was a mediator of the effect of participation score on stunting reduction.

Water sources as mediator.

Mother's SPA was significantly associated with WS (Table 3). Compared to a household having drilling system as WS, the increase of score of participation was likely associated with a low proportion of household having source Covered Well (OR: 0.90; P=0.003) and to a high proportion of households having Tap (OR: 1.04, P=0.036).

From Table 3 and model 3, we do not have sufficient proof to consider WS as a mediator of the effect of SPA on stunting prevalence (Sobel's test, P=0.13)

EBF as moderator.

In the moderation regression, we found that the coefficient of interaction EBF with SPA ("EBFYes:SPA") was significant (P=0.034). Therefore, EBF was a mod-
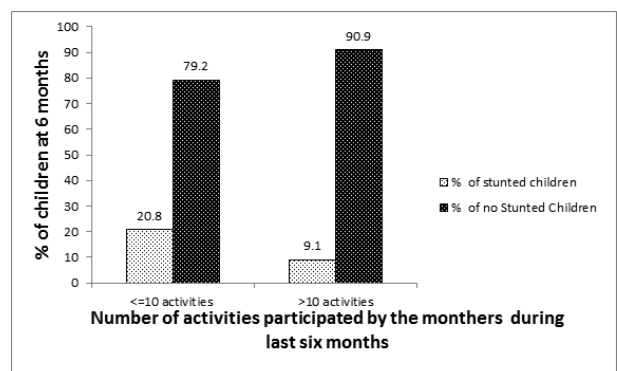
Figure 2. Distribution of children at 6 months age by score of participation in activities and by stunting group or not. % of stunted children is low in mother who have participated in more 10 actitivites of N@C project.

Table 2. EBF as not mediator of SPA effect on 6 months stunting prevalence

Independent variables	Stunting and Score of Participation (1)		EBF and Score of Participation (2)		EBF as Mediator (3)	
	Dependent variables					
	Stunting		EBF		Stunting	
		P		P		P
SPA	−0.076	0.009	0.139	0.0001	−0.066	0.035
EBFYes	–		–		−0.344	0.409
Constant	−1.025	0.0003	−0.564	0.019	−0.906	0.004

( ): coefficient estimate, SPA; Score of Participation in N@C activities; EBF: Exclusive breastfeeding; Number of Observations: 213
Model 1: Logistic regression with SPA as independent variable and Stunting, dependent Variable
Model 2: Logistic regression with SPA as independent variable and EBF, dependent Variable
Model 3: Logistic regression with SPA and EBF as independent variables and stunting, dependent Variable

erator of SPA effect on 6 months stunting prevalence (Table 4). The children whose mothers increased their participation and practiced EBF were less likely to be stunted (OR: 0.87; 95% IC: 0.77-0.98) compared to those whose mothers did not practice EBF and did not participate in the activities.

Moreover, while the score of participation increased and the mothers did not practice EBF, 6 months stunting prevalence increased from 21.4% to 26.8%. However, when SPA increased and the mothers practiced EBF, the 6 months stunting prevalence decreased from 31% to 1.9% (Figure 3).

Stunting adjusted prevalence is decreasing among mothers who practiced EBF.

Children whose mothers participated in nutritional activities and got water from uncovered wells or streams were more likely to be stunted (OR: 1.28; 95% IC : 1.05-1.63) compared to those who got water source from the drilling system and participated in the activities (Table 4).

We noticed that, while the SPA increased and the WS becomes drilling system, covered well, and tap, the stunting prevalence, respectively, decreased by 15.6%, 26.9%, and 45.4%. Additionally, while the SPA increased and the WS was uncovered well or stream, stunting prevalence in the community increased by 72.4% (Figure 4). Stunting adjusted prevalence is decreasing among mothers who have drilling system, covered well and tap like water sources.

WS as moderator

**Table 3.** Water source as not mediator of SPA effect on 6 months stunting prevalence

	Covered well		Uncovered Well and Stream		Tap	
	Dependent variables					
		P		P		P
Water source with score of participation, Model 2						
SPA	−0.103	0.003	−0.043	0.225	0.043	0.036
Constant	−0.045	0.879	−1.180	0.003	−0.654	0.022
Water source as Mediator, Model 3*						
	0.835	0.143	1.164	0.012	1.142	0.028
Constant	−1.756	0.0001				

( ): coefficient estimate SPA; Score of Participation in N@C activities; Number of observations: 213.
Model 2: Logistic regression with SPA as independent variable and Water Source types, dependent Variable. Reference is Drilling system water
Model 3: Logistic regression with SPA and Water Sources Types as independent variables and stunting, dependent variable
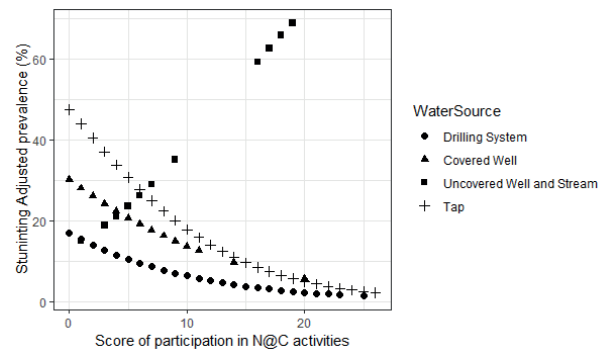* The confidence interval of the effect from Monte-Carlo simulation is 0.002 to 0.13. In addition, we implemented Sobel's test and got a *P* = 0.13 with a confidence interval from 0.014 to 0.114. Thus, we do not have the proof to consider Water Source as a mediator of the effect of score on stunting proportion.
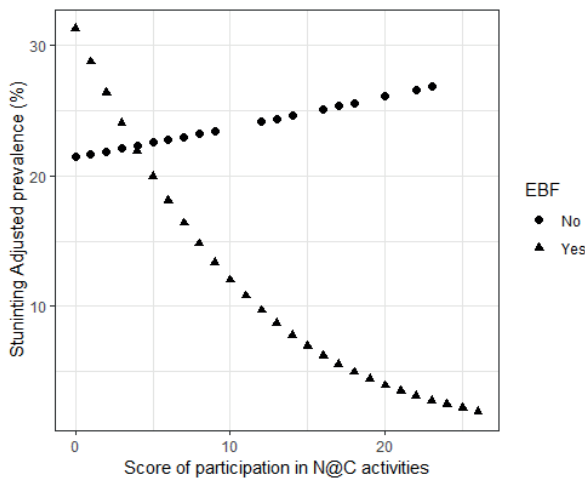
Figure 3. EBF as moderator of participation in N@C activities effect on children stunting prevalence at 6 months age.

Discussion and conclusion

Mainly, this study checked the role of EBF and WS in the effect of N@C project on stunting preva-

Table 4. EBF and Water source as moderators of SPA effect on 6 months stunting prevalence

	Stunting as dependent variable	
		P
EBF and SPA as independent variables, model 4		
Independent variables		
EBFYes	-0.796	0.068
SPA	0.013	0.772
EBFYes : SPA	-0.133	0.034
Constant	-1.174	0.0004
Water Source and SPA as independent variable, model 4		
SPA	-0.109	0.121
Covered well	0.754	0.359
Uncovered well and stream	-0.284	0.794
Tap	1.499	0.048
SPA: Covered Well	0.009	0.941
SPA:Uncovered well,stream	0.250	0.023
SPA : Tap	-0.034	0.700
Constant	-1.999	0.004

Model 4: Logistic regressions with EBF or Water Source and Participation Score as independent variables and Stunting as dependent variables. SPA: Score of Participation in N@C Activities; EBF: Exclusive breastfeeding; coefficient of regression; Number of observations: 213.

Figure 4. Water source is moderator of participation in N@C activities effect on children stunting prevalence at 6 months age

lence in the implementation community. Firstly, we found that there is a significant difference in 6 months stunting prevalence between the intervention zone of N@C and Non- intervention zone (p=0.0003). Then, to understand how that influence happens, we pointed out EBF and WS as mediators or moderators. We noticed that the prevalence of stunting decreased in their community when mothers participated in activities and practiced EBF or used the improved WS, while those who did not practice EBF or they used drink water from non-covered wells had a slight increase of stunting prevalence.

Firstly, EBF is considered as moderator of the effect of participation score on the reduction of stunting at 6 months. This is consistent with the known advantages of EBF and WHO recommendations on the EBF practices. Actually, in the community where mothers have participated in activities SBCC but do not practice EBF and give water, herb teas, and even food to their children, they still expose their health to increased infection, morbidity (8), which would increase the probability to be stunted. Consequently, participation in activities would have a considerable effect on the reduction stunting if the mothers practiced effectively the EBF (8). The results revealed the low effect in the reduction of stunting considering SBCC interventions. Methods to assess better EBF practices needs to be reinforced for better EBF promotion.

We noticed that "EBF" is not an intermediate of the effect of participating in SBCC and the reduction of stunting at 6 months. This result is straight with some studies that showed that EBF was not associated with stunting. In Gambia, the following of EBF

up to 6 months, had limited effect on linear growth (24). Secondly, we found that WS is a moderator of the effect of participating in SBCC on stunting reduction at 6 months. Generally, the quality of water is an essential point in child feeding practices. Furthermore, it needs to be taken into account to set policies about stunting reduction (25). Unsafe water as well as poor conditions of hygiene and sanitation has a significant detrimental effect on child growth and development (6). A meta-analysis found that water, sanitation, and hygiene interventions were associated with increased height-for age z scores (25). However, specifically, in our study we focused on WS, because it is a compulsory predictor when it is about the health of children (7). We found again that WS might be a mediator, but after testing the indirect effect, we did not get a significant value. However, WS is still a moderator explaining better when the effect happens. A community in which mothers have participated in activities and used "Drilling System", "Covered Wells", or "Tap" has a lesser probability to get stunted children and those with "Non Covered Wells Stream" got a higher probability. WS reflects the health risk of a child (26, 27), especially the one of its mother. A mother who drinks dirty water might fall sick and not be able to take care of her child (28). An appreciated WS is advisable due to the fact that very uncertain water sources might positively influence the stunting prevalence in a given community even though they are advised to avoid them. Feeding mothers better get water from drinkable sources. This situation might explain the findings in our research that stipulate how WS changes the influence SBCC on stunting prevalence reduction in a community. Considering only the source of water "Tap" without any training, the risk of being stunted is greater compared to those using a drilling system. The emphasis is that our score does not consider only EBF or WS advices sessions but the whole implementation package. And a child whose mother is well trained but continues to get water from dirty sources is more likely to be stunted compared to those getting water from a drilling system.

The aforementioned evidences showed that the more mothers in a community practice EBF and other trainings about nutritional activities like getting wa-

ter from drinkable sources and the lesser it encounters children's stunting cases. The interaction analysis shows also that good practices (EBF, drinkable water source) are strongly associated with the improvement of a child nutritional status in a community.

Limits of the study

In our work, we had children aged 6 months and the term "stunting" at that age is not really detectable. Actually, at 6 months, children are at risk of being stunted (18). This work may link EBF and water source to deepen the checking, but it did not due to its objectives. The category "Non Covered Wells Stream" frequency is not too great and this can blur its variability compared to the other groups from water source. Finally, the variable score took into account only the number of activities a woman attends. To better its variability, it could consider how frequently a woman is in each of the nutritional activities.

Mediation analysis can be challenged by many other faulty relations among variables that can make researchers misunderstand a third variable causal effect. Simulation studies showed that this type of analysis can lead to faulty conclusions. Actually, a variable which is not a real mediator can mimic one. Besides, when we test the indirect effect, we just look for the significance of those values and not the existence of the mediator or not. However, at the same time, correlational analyses are not generally inferior to experimental analysis because they help to cancel some causal constellations that experimental designs would conceal (29).

In conclusion, the effect of N@C project on the reduction of stunting at 6 months is moderated by the EBF practices and WS. The effective practice of EBF and use of appropriate drinking water in a household could help stunting reduction programs. The whole implication of this study is that it seems that the effect of N@C project on the reduction of prevalence stunting at 6 months will be more perceptible if the mothers effectively practice EBF and their household use the appropriate water source.

N@C project. We also thank the field supervisors of data collection, Ballo C., Kossou J., Metodakou R., and Dansou B.

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