Badaru *et al.*
Bulletin of Faculty of Physical Therapy (2023) 28:2
https://doi.org/10.1186/s43161-022-00113-8

Bulletin of Faculty of Physical Therapy

ORIGINAL RESEARCH ARTICLE Open Access

Influence of malnutrition and body composition on the gross motor function of children with cerebral palsy in Kano, Nigeria: a cross-sectional study

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Abstract

Background: Malnutrition is common among children with cerebral palsy (CWCP); however, its impact on gross motor function (GMF) is not adequately reported. The study evaluated the influence of malnutrition and body composition on GMF.

Methods: In the cross-sectional survey, CWCP were recruited using purposive sampling from three selected secondary and tertiary hospitals in Kano, Nigeria. Sociodemographic variables were recorded on a data capture form. Anthropometric variables were measured using standard procedures. Percent (%) body fat, malnutrition, and GMF were assessed using skinfold thickness, screening tool for the assessment of malnutrition in pediatrics, and GMF classification system (GMFCS), respectively. The data was analyzed with one-way ANOVA, chi-square, and logistic regression using SPSS version 20 at $p < 0.05$.

Results: The 146 CWCP have mean age of 4.70 ± 2.46 years. About 95 (65.1%) are malnourished. Those with GMFCS V had lower %body fat and higher malnutrition than children with GMFCS II and I, respectively ($p < 0.05$). Malnutrition has no significant influence on GMF ($B = 0.984$, $OR = 2.676$; 95% $CI = 0.965–7.423$, $p > 0.05$). %body fat ($B = -0.192$, $OR = 0.826$; 95% $CI = 0.687–0.992$, $p < 0.05$), type of CP ($OR = 12.106$; 95% $CI = 3.771–38.866$, $p < 0.005$), child's position in the family ($OR = 1.639$; 95% $CI = 1.162–2.312$, $p < 0.05$), and mothers' education ($B = -2.815$, $OR = 0.060$; 95% $CI = 0.012–0.309$, $p < 0.005$) all predicted GMF.

Conclusions: Majority of the CWCP in this study are malnourished. But malnutrition did not however significantly predict GMF, meaning that though malnutrition could impair children's physical growth and motor development, it however did not have significant influence on their motor function. Hence, CWCP undergoing rehabilitation may not likely experience significant decrease in their motor function due to inadequate nutrition. Decrease in body fat, type of CP, low level of mothers' education, and child occupying 4th or more position in the family have negative influence on GMF. It was recommended that physiotherapists should routinely assess for malnutrition in CWCP. Prompt nutritional intervention may prevent considerable lose of body fat and augment the gains of physical rehabilitation

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by providing appropriate nutrition to support muscle growth and the supply of adequate energy for participation in physical exercise. Adequate caregiver education is important for ensuring satisfactory nutrition for CWCP.

Keywords: Cerebral palsy, Gross motor function, Malnutrition, Body composition, Children

Background

Good nutrition is essential for physical growth and motor development in children [1]. It enhances growth and maturation of the central nervous system and musculoskeletal system and strengthens the immune system [2, 3]. Malnutrition has on the other hand been considered a major health problem worldwide, and nutritional deficiencies are common in children with CP (CWCP) [4–7]. There is a high prevalence of malnutrition among CWCP [1, 7] which ranges from 52.9% [6], 56.4% [8], and 86% [1]. Studies have reported that some of the predisposing factors to malnutrition in CWCP could include child's age [7–9], cognitive impairment, inadequate energy intake [8], low family income [9], and low maternal education [7]. Other studies have however revealed that severity of motor impairment is the single most important predisposing factor to severe malnutrition in CWCP [6, 7, 10]. The outcome of a study [6] has highlighted further that deterioration in gross motor function (GMF) increased the risk of severe malnutrition in CWCP. Children with severe GMF such as quadriplegia and mixed CP types could suffer malnutrition due to the presence of associated disorders such as dysphagia with impaired sucking and swallowing [3, 11, 12], gastroesophageal reflux disease, and chronic constipation [13].

On the other hand, malnutrition has been reported to lead to impaired physical growth [4, 14] and altered body composition [5, 15, 16] manifesting as underweight, stunting, and wasting [1, 8]. It also has negative influence on physical and intellectual development and social and emotional abilities [17]. According to a research finding, malnutrition leads to deterioration of motor abilities and poor muscle strength in infants and children respectively [18].

Empirical findings have suggested that deterioration of GMF has negative impact on nutrition in CWCP, meaning that what obtains presently in the literature is that children with severe CP (poor GMF) are more predisposed to having severe malnutrition [6, 7, 10]. These findings have implied that improvement in GMF (reduction in severity of CP) is likely to lead to improvement nutrition in CWCP. These studies have probably looked at only one side of the coin. Because it is also likely that CWCP who are ambulant may lose the ability to walk if they become severely malnourished, but the possible impact malnutrition could have on the motor function of CWCP is yet to be made clear in the literature. To support our claim, an intervention study has revealed that enhanced nutrition (which improved lean muscle tissue) has positive impact on GMF in CWCP [13]. Malnutrition has previously been linked to a deterioration in muscle strength [18–20], muscle wasting [1, 8], and impairments of muscle growth and cognitive function [3, 12]. But studies are yet to report on the likely influence of malnutrition and body composition on GMF in CWCP. The outcome of this study may highlight the need for rehabilitation experts to include routine nutritional assessment and therapy in the comprehensive care for CWCP. It may therefore suffice in this regard to study the impact of malnutrition and body composition (percent body fat and body mass index [BMI]) on GMF in CWCP.

Aim and objectives of the study

The main aim of this study was to evaluate the influence of malnutrition and body composition on GMF in CWCP. The specific objectives are to assess the following:

1. The influence of percent body fat and BMI on GMF
2. The influence of child's characteristics (age, sex, and position in the family) on GMF
3. The influence of mother's characteristics (age and level of education) on GMF

Methods

The design of the study was cross-sectional survey in which CWCP attending outpatient units of the Physiotherapy and Pediatric Departments of Murtala Muhammad Specialist Hospital, Muhammad Abdullahi Wase Teaching Hospital, and Hasiya Bayero Pediatric Hospital in Kano, Nigeria, were recruited using purposive sampling. The inclusion criteria include the following: CWCP across all Gross Motor Function Classification System (GMFCS) categories and those who are 2 years of age and above (because the weight and height centile tables for the assessment of malnutrition were designed for children who are aged 2 years and above). The exclusion criteria include the following: CWCP who also have other comorbid conditions such as severe pulmonary tuberculosis, severe pneumonia, HIV, or cancers that could predispose them to severe weight lost and malnutrition. Also, children with musculoskeletal deformity affecting both lower limbs that make anthropometric measurement of height unreliable were

excluded. Ethical approval was sought and obtained from ethics committee of the Kano State Ministry of Health. The research procedure was explained to each of the mothers, and their consents were obtained. They were then asked to sign an informed consent form. Sociodemographic information such as mother's age, level of education, and monthly family income and child's age, sex, and position in the family were obtained from the parents via oral interview. Anthropometric measurement of the children's weight to the nearest 0.1 kg and height to the nearest 0.1 cm was measured using stadiometer (Seca, Germany). For children who are unable to stand, their weights were calculated as the difference between the weight of the parent holding the child and the weight of the parent alone. Length measuring board was used to measure height for the children who cannot to stand. Recumbent lengths were converted to height by subtracting 0.7 cm from the recumbent length [11]. The BMI (in kg/m^2) was determined by dividing body weight (in kg) by the square of the height (in meters). Percent body fat was assessed with skinfold caliper over the triceps, calf, and scapular to the nearest 0.1 mm. Percent body fat was calculated using Slaughter's equation [21]. A previous study has encouraged the use of skinfold thickness measurement in CWCP [22]. Malnutrition was assessed with the Screening Tool for the Assessment of Malnutrition in Paediatrics (STAMP) [23]. Stamp was previously validated for use in the outpatient setting and has sensitivity of 76.19% and specificity of 82.05% [24]. In this study, STAMP was pretested on a sample of 37 CWCP; it yielded a Cronbach's alpha of 0.71. It was scored as follows:

1. The diagnosis of CP attracts a score of 2 points.
2. Nutritional intake: None (3 points), poor (2 points), and good (0 point)
3. Number of centiles apart between height and weight: > 3 centile spaces (3 points), > 2 centile spaces (2 points), and 0 to 1 centile spaces (0 point)
4. Risk of malnutrition is obtained by adding the values gotten from steps 1 to 3. Highly risk of malnutrition score > 4, medium risk 2–3, and low risk 0–1.

The GMF was assessed with GMFCS; the 5-point ordinal scale was scored from 1 to 5. Lower scores mean better GMF as follows:

I. Walks without restrictions
II. Walks without assistive devices and limitations walking outdoors and in the community
III. Walks with assistive mobility devices
IV. Children are transported or use powered mobility
V. Self-mobility is severely limited [25]

Sample size determination

A total sample size of 143 participants was determined for linear regression using G*Power software, with medium effect size $f^2 = 0.15$, $P = 0.05$, power = 89%, and a total of 10 predictors (mother's age, mother's education, family income, child's age, child's sex, position of the child in the family, type of cp, malnutrition risk, BMI, and percent body fat). Therefore, a total of 146 CWCP were recruited for the study. A medium effect size of 0.54 based on Cohen's criteria for paired *t*-test was obtained from the outcome of GMF values in another study [13]. In the G*Power software, the default medium effect size for *F*-tests linear regression was $f^2 = 0.15$ [26].

Data analysis

The data was summarized using descriptive statistics of mean, standard deviations frequency, and percentages. One-way ANOVA was used to find difference in %body fat, malnutrition score, and BMI across the GMFCS categories. Chi-square was used to determine the association between selected variables (malnutrition risk, BMI, %body fat, child- and mother-related factors) and GMF. Logistic regression was used to find predictors of GMF. For the purpose of chi-square and logistic regression analyses, the dependent variable (GMF) was dichotomized into GMFCS I-III (ambulant) and GMFCS IV-V (non-ambulant). The mean score was used to dichotomize the following continuous variables for the purpose of chi-square analysis: mean age of children 4.70 ± 2.46 years (dichotomized as < 5 years and ≥ 5 years), BMI 16.19 ± 2.76 kg/m^2 (dichotomized as < 16 kg/m^2 and ≥ 16 kg/m^2), percent body fat 7.99 ± 3.54% (dichotomized as < 8% and ≥ 8%), and position of the child in the family 3.55 ± 2.57 (dichotomized as < 4 and ≥ 4). Type of CP such as monoplegia, diplegia, and hemiplegia was categorized as "less than 4 limbs affected," while quadriplegia was categorized as "4 limbs and trunk affected." Finally, mean age of the mothers 31.24 ± 7.65 years was dichotomized as < 31 years and ≥ 31 years. For mother's education, nonformal, primary, and secondary education were considered "low education," while tertiary education was considered "high education." All statistical analyses were conducted using SPSS version 20. Statistical significance was set at an alpha level of 0.05.

Results

One-hundred and forty-six (146) CWCP participated in the study. Their age ranged between 2 and 12 years, mean 4.70 ± 2.46 years. The mean scores of their BMI and percent body fat were 16.19 ± 2.76 kg/m^2 (range

8.16–23.73 kg/m^2) and 7.99 ± 3.54% (range 1.51–21.21%), respectively. Ninety-five of the children (65.1%) were at high risk for malnutrition, 40 (27.4%) have GMFCS score of 4, and 48 (32.9%) have GMFCS score of 5 as presented in Table 1. The mean age of their mothers was 31.24 ± 7.65 years, range 18–46 years. About 93 (63.7%) of the mothers had secondary level education as presented in Table 1.

One-way analysis of variance revealed that there was significant differences in percent body fat F(4) $p < 0.05$ and malnutrition risk score F(4), $p < 0.05$, based on GMFCS levels. Children in GMFCS 5 had significantly lower %body fat and significantly higher malnutrition risk than children in GMFCS 2 and GMFCS 1 categories respectively (Table 2).

Table 3 showed that there was significant association between gross motor function and each of child's position in the family $\chi^2 = 4.59$, $p < 0.05$; type of CP $\chi^2 = 32.38$, $p < 0.005$; malnutrition risk, $\chi^2 = 9.61$, $p < 0.0050$; percent body fat, $\chi^2 = 3.86$, $p < 0.05$; and mother's education level $\chi^2 = 30.33$, $p < 0.005$.

Results showed that the model for logistic regression was worthwhile with a significant value for Omnibus Tests of Model Coefficients χ^2 (9) = 81.07, $p < 0.005$, and a nonsignificant value for Hosmer-Lemeshow goodness-of-fit test χ^2 (8) = 8.835, $p > 0.05$, indicating the model performs very well. The Cox & Snell R^2 and Nagelkerke R^2 are 0.426 and 0.576, respectively, which showed that the model explained 42.6% and 57.6% of the variance in GMF.

The factors influencing gross motor function in CWCP are mothers' level education ($B = -2.815$, odds ratio (OR) = 0.060; 95% confidence interval [CI] = 0.012–0.309, $p < 0.005$), type of CP ($B = 2.494$, $OR = 12.106$; 95% $CI = 3.771–38.866$, $p < 0.005$), malnutrition risk ($B = 0.984$, $OR = 2.676$; 95% $CI = 0.965–7.423$, $p > 0.05$), %body fat ($B = -0.192$, $OR = 0.826$; 95% $CI = 0.687–0.992$, $p < 0.05$), and child's position in the family ($B = 0.494$, $OR = 1.639$; 95% $CI = 1.162–2.312$, $p < 0.05$) as presented in Table 4

Table 1 Sociodemographic characteristics of the study participants ($N = 146$)

Variables	Frequency = *n*	Percentage (100%)
Mother's age category		
11–20 years	7	4.8
21–30 years	75	51.4
31–40 years	43	29.5
41–50 years	21	14.4
Mothers education level		
Non formal	5	3.4
Primary	25	17.1
Secondary	93	63.7
Tertiary	23	15.8
Family income		
Not disclosed	82	56.2
Below minimum	23	15.8
Low income	33	22.6
Moderate income	4	2.7
High income	4	2.7
Child's position in the family		
1st–4th	102	69.86
5th–8th	34	23.29
9th–12th	10	6.85
Child's age category		
2–5.9 years	98	67.1
6–9.9 years	41	28.1
10–13.9 years	7	4.8
Child's sex		
Male	67	45.9
Female	79	54.1
Type of CP		
Monoplegia	7	4.8
Hemiplegia	55	37.7
Diplegia	22	15.1
Quadriplegia/mixed CP	62	42.5
Malnutrition risk		
Medium risk	51	34.9
High risk	95	65.1
Gross motor function		
GMFCS 1	14	9.6
GMFCS II	15	10.3
GMFCS III	29	19.9
GMFCS IV	40	27.4
GMFCS V	48	32.9

GMFCS gross motor function classification system, *CP* cerebral palsy, *N* sample size

Discussion

In this study, 27% of the CWCP have GMFCS score of 5 and 33% having score 5 indicating that 60% of the children in this study are non-ambulant (having severe CP). In addition, 65% of the CWCP in this study have high risk of malnutrition. The finding on malnutrition is in consonance with previous research reports where malnutrition was reported to be highly prevalent among CWCP especially in the low- and middle-income countries [1, 7]. Furthermore, when compared to the outcome of another study [22], many of the CWCP in this study have low percent body fat and are underweight. The possible reason for this outcome is probably because malnutrition is likely to predispose to emaciation with depletion of body fat, growth restriction, and underweight [27].

Table 2 Differences in malnutrition risk and body composition across the gross motor function levels

	GMFCS I	GMFCS II	GMFCS III	GMFCS IV	GMFCS V	df	*F*-ratio	*p*-value
Percent body fat	8.72 ± 3.52	10.11 ± 4.23[a]	9.04 ± 4.60	7.52 ± 2.51	6.88 ± 2.88[b]	4	3.78	0.006*
Malnutrition risk score	3.36 ± 1.34[a]	3.87 ± 1.19	4.00 ± 1.36	4.43 ± 1.45	4.67 ± 1.21[b]	4	3.55	0.009*
Body mass index	15.99 ± 1.93	16.01 ± 3.37	16.81 ± 2.75	15.98 ± 2.45	16.11 ± 3.04	4	0.45	0.769

Key *significant. Post hoc analysis with Bonferroni correction showed that items with superscripts are significantly different. *GMFCS* gross motor function classification system

Table 3 Association between gross motor function, malnutrition risk, and each of child and caregiver-related variables ($N = 146$)

Variables	Total *N*	GMFCS 1–111 *N* (%)	GMFCS IV–V *N* (%)	χ^2/Fishers exact	*P*
Child's age category					
< 5 years	82	30 (36.59)	52 (63.41)	0.77	0.38
≥ 5 years	64	28 (43.75)	36 (56.25)		
Child's sex					
Male	67	27 (40.30)	40 (59.7)	0.017	0.90
Female	79	31 (39.24)	48 (60.76)		
Child's position in the family					
< 4th position	85	40 (47.06)	45 (52.94)	4.57	0.033*
≥ 4th position	61	18 (29.51)	43 (70.49)		
Type of CP					
Less than 4 limbs affected[a]	84	50 (59.52)	34 (40.48)	32.38	0.000**
Four limbs and trunk affected[b]	62	8 (12.90)	54 (87.10)		
Malnutrition risk					
Medium risk	51	29 (56.86)	22 (43.14)	9.61	0.002**
High risk	95	29 (30.53)	66 (69.47)		
Percent body fat					
< 8%	80	26 (32.5)	54 (67.5)	3.86	0.049*
≥ 8%	66	32 (48.48)	34 (51.52)		
BMI					
< 16 kg/m^2	74	30 (40.54)	44 (59.46)	0.042	0.84
≥ 16 kg/m^2	72	28 (38.89)	44 (61.11)		
Mother's education					
Low education	123	37 (30.08)	86 (69.92)	30.33	0.000*
High education	23	21 (91.30)	2 (8.70)		
Mother's age					
< 31 years	81	31 (38.27)	50 (61.73)	0.161	0.69
≥ 31 years	65	27 (41.54)	38 (58.46)		

BMI body mass index

*$p < 0.05$, **$p < 0.005$. *GMFCS* gross motor function classification system

[a] Monoplegia, hemiplegia, or diplegia

[b] Quadriplegia

Another finding in this study revealed that CWCP who are non ambulant had significantly lower percent body fat and higher malnutrition risk than those who are ambulant. This implied that children with more severe CP experienced significant malnutrition when compared with those having less severe CP. The finding is in line with the outcome of another study in which undernutrition was associated with more severe CP [6]. CWCP in the GMFCS categories IV and V aside from having severe motor impairment that makes them inactive are more likely to suffer from malnutrition due to oropharyngeal dysphagia and other gastrointestinal issues including

Table 4 Predictors of gross motor function in CWCP ($N = 146$)

Variable	*B*	Wald	Exp(B)	95% *CI*	*p*-value
Mother's age (raw scores)	−0.123	2.973	0.884	0.768–1.017	0.085
Mother's education (0 = low, 1 = high)	−2.815	11.331	0.060	0.012–0.309	0.001**
Child's age (raw scores)	−0.110	0.468	0.896	0.655–1.227	0.494
Child's sex (1 = male, 2 = female)	0.748	1.863	2.114	0.722–6.190	0.172
Type of CP (0 = < 4 limbs affected, 1 = 4 limbs affected)	2.494	17.558	12.106	3.771–38.866	0.000**
Malnutrition risk (0 = medium risk, 1 — high risk)	0.984	3.577	2.676	0.965–7.423	0.059
BMI (raw scores)	0.015	0.026	1.015	0.843–1.223	0.873
Percent body fat (raw scores)	−0.192	4.169	0.826	0.687–0.992	0.041*
Child's position (raw scores)	0.494	7.912	1.639	1.162–2.312	0.005*
Constant	2.893	2.286	18.045		0.131

*Significant at $p < 0.05$. **Significant $p < 0.005$. < 4 limbs affected: monoplegia, hemiplegia, or diplegia. Four limbs affected: quadriplegia. Exp(B): odds ratio. *CI* confidence interval. Dependent variable: gross motor function (0 = ambulant, 1 = non ambulant)

constipation [11, 12] that could predispose them to inadequate food consumption [8], whereas those in the GMFCS categories I and II are more physically active and higher levels of participation in physical activities are likely to stimulate food consumption and encourage better nutrition.

This study found that significant association exists between malnutrition and GMF which implied that malnutrition has relationship with GMF based on the outcome of chi-square analysis. But the outcome of logistic regression analysis which is more robust than chi-square showed that malnutrition marginally predicted GMF. The odds ratio (OR) of 2.676 means that the odds of deterioration in GMF is 2.676 times higher for CWCP with high malnutrition when compared with those having moderate malnutrition risk; however, the OR is not significant statistically. It means that malnutrition does not have significant influence on GMF. This finding further means that though malnutrition has previously been reported to have negative impact on physical growth, cognitive function [17], muscle strength, and motor function [18], it, however, does not have significant influence on the GMF of CWCP.

It was further observed in this study that there was significant association between percent body fat and GMF in which majority of the CWCP who have low percent body fat are more likely to experienced deterioration of their GMF based on the result of chi-square analysis. Also, the outcome of logistic regression analysis showed that percent body fat significantly predicted GMF. Negative beta value means that decrease in percent body fat significantly predicted higher GMF scores (or severe deterioration of GMF). The OR of 0.826 means that for every 1% decreases in body fat, the odds for deterioration in motor function (higher GMF score) increase by a factor of 0.826, other factors being equal. The clinical implication of this finding is that CWCP with severe reduction in percent body fat due to malnutrition may experience deterioration in GMF. It further implies that body composition has significant influence on GMF in CWCP.

More so, it was found that significant association exists between type of CP and GMF. The outcome of logistic regression analysis showed that the type of CP in which all the four limbs and trunk are affected significantly predicted higher GMF scores or nonambulation. The clinical implication of this finding is that the type of CP particularly the number of limbs affect by CP is also a significant predictor of GMF.

The outcome of regression analysis showed that child's position in the family is a significant predictor of GMF. Positive beta value means that for CWCP who are born late (by occupying 4th position or more), 1.639 odds have higher GMF score (non ambulant) when compared with CWCP who occupy less than the 4th position in a family without many children. The dwindling economic fortunes of countries like Nigeria over the years couple with cultural practices of polygamy have left many families poor with many mouths to feed, and this is likely to have significant negative impact on the outcome of care for CWCP who are born into these families. Hence, a child born into such families may not get the optimal care needed for improvement of GMF.

Finally, mother's education significantly predicted GMF. Negative beta value means that low level of mother's education significantly predicted higher GMF scores (deterioration of motor function). The OR of 0.060 means that, for every one level decrease in mother's education, the odds for CWCP to have higher GMF score (deterioration of motor function) increase by a factor of 0.060, other factors being equal. The possible

implication of this finding is that parent education level is likely to have significant influence on GMF because only educated individuals could appreciate the implication of their child's diagnosis, seek appropriate medical care at the appropriate time, seek extra knowledge about the condition, and are more likely to adhere to prescribed treatment regimen [7].

Finally, it is important to note that model of logistic regression in this study only accounted for less than 60% of the variance in GMF. Possibly, other factors not assessed in the present study may have accounted remaining variance not explained by the model. For example, previous studies have revealed that GMF in CWCP was negatively influenced by impairments of vision [28] and speech [29, 30].

Conclusions

Majority of the CWCP in this study are malnourished. But malnutrition did not however significantly predict GMF, meaning that though malnutrition could impair children's physical growth and motor development, it however did not have significant influence on their motor function. Hence, CWCP undergoing rehabilitation may not likely experience significant decrease in their motor function due to inadequate nutrition. Decrease in body fat, type of CP, low level of mothers' education, and child occupying 4th or more position in the family have negative influence on GMF. It was recommended that physiotherapists should routinely assess for malnutrition in CWCP. Prompt nutritional intervention may prevent considerable lose of body fat and augment the gains of physical rehabilitation by providing appropriate nutrition to support muscle growth and the supply of adequate energy for participation in physical exercise. Adequate caregiver education is important for ensuring satisfactory nutrition for CWCP.

Abbreviations

CP: Cerebral palsy; CWCP: Children with CP; GMFCS: Gross motor function classification system; GMF: Gross motor function; BMI: Body mass index; %: Percent.

Authors' contributions

UMB and ALU conceptualized and designed the study. UMB, ALU, AA, JSU, and OOO were involved in data acquisition, analysis, and interpretation. The first draft of the manuscript was written by UMB and ALU which was reviewed by OOO and AA. All the authors approved the final manuscript.

Funding

The study was sponsored by the authors.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Ethics clearance was sought and obtained from the Ethics Committee of Kano State Ministry of Health, Kano, Nigeria (NHREC/17/03/2018), Ref. SHREC/2021/2453. Also, written consent of participation was sought and obtained from the study participants.

Consent for publication

The written consent given by the participants included permission to publish the research outcome.

Competing interests

The authors declare that they have no competing interests.

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Received: 28 July 2022 Accepted: 15 October 2022
Published online: 04 January 2023

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