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Research

Process and outcome of a four-week garden-enhanced nutrition education programme to improve knowledge and vegetable consumption of school-age children in Ibadan, Nigeria

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Background

Diets of school-age children are increasingly becoming energy-dense, coupled with the poor consumption of vegetables and fruits. This situation predisposes them to malnutrition and non-communicable diseases. A garden-enhanced nutrition education programme was therefore designed to promote knowledge and consumption of vegetables.

Objective

To design a garden-enhanced nutrition education programme to promote knowledge and consumption of vegetables.

Methods

A 4-week garden-enhanced nutrition education pilot programme tagged 'Kids Nutri-garden Vacation School (KNGVS) was implemented during the long vacation of elementary schools. School-age children 6 – 11 (n=24) participated in the programme. The intervention included weekly outdoor and indoor activities of hands-on vegetable gardening, nutrition education lessons, and a cooking demonstration session. Data on nutrition knowledge, asking behaviour and consumption of vegetables were obtained at baseline (pre-test), endline (post-test) and six weeks follow-up and compared using one-way ANOVA. Qualitative data on parents' perception of the intervention programme was obtained and reported thematically.

Results

There was a statistically signifcant increase in nutrition knowledge scores: pre-test = 39.2±9.1, post-test = 48.3±6.7, which was maintained at the 6-week follow-up = 48.9±4.4, F=13.45, p<0.00). The number of children who reported that they ate vegetables always also increased: pre-test =12.5%, post-test = 20.8%, follow-up = 33.3%. All parents (100%) reported that their children had become more conscious of consuming vegetables and healthy food choices to a great extent.

Conclusions

The garden-enhanced nutrition education approach is a promising food-system related framework that provides a window of opportunity for influencing knowledge and practice of healthy eating among school-age children in developing countries like Nigeria. It leverages hands-on learning to give the children first-hand experience on the linkages between nutrition, health, agriculture and the environment at different levels of social interaction. There is a need to test this framework further while implementing it at a larger scale within the regular primary school academic calender.

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INTRODUCTION

Dietary habits of school-age children in Nigeria are of utmost concern today because of an increased intake of energy-dense foods, which are high in saturated fats, sugars, and refined carbohydrates and low in vegetables and fruits (Sanusi et. al. 2022). Low intake of vegetables and fruits, and physical inactivity contribute to the rising incidence of non-communicable diseases (NCDs) in adulthood (Storz and Heymann, 2017). In Nigeria, NCDs such as obesity, diabetes mellitus, cardiovascular diseases, and cancers are emerging problems currently accounting for about 29% of all deaths in the country (WHO, 2018). Furthermore, micronutrient malnutrition among children still remains a public health challenge in Nigeria due to poor dietary habits (Sanusi et. al. 2022; Harika et. al. 2017). Research suggests that dietary habits acquired in childhood are carried into adulthood (Oldewage-Theron and Egal, 2010) with serious health, social, and economic implications. Therefore, shaping dietary habits (such as consumption of healthy foods like vegetables and fruits) of young children early to prevent poor health outcomes and malnutrition is important.

Previous studies support the hypothesis that home and/or school gardens, combined with other nutrition and/or culinary education interventions, are successful in improving healthy eating habits, especially intakes of vegetables and fruits of children (Davis et. al. 2023; Scherr et. al. 2017; Somerset and Markwell, 2009; Morgan et. al. 2010; Parmer et. al. 2009; Langellotto and Gupta, 2012; Yoder et. al. 2014; Heim et al. 2009). This is especially true for vegetables, for which many children have low preferences when compared to fruits (Yoder et. al. 2014; Bandura, 1986). The garden is a small food system that functions as an experiential learning space where children participate in a "seed to table" approach to eating (Heim et al. 2009) thereby increasing their exposure to and consciousness of vegetables. This is conceptualized in the garden-enhanced approach to nutrition education for children as an effective strategy to improving their nutrition knowledge and willingness to taste and consume vegetables and fruits (Scherr et. al. 2017; Morgan et. al. 2010; Parmer et. al. 2009; Langellotto and Gupta, 2012; Yoder et. al. 2014); it also provides long-term visual reinforcement of healthy behaviours (Parmer et. al. 2009). Relevant theoretical approaches to garden-enhanced nutrition education include the Social Cognitive Theory (SCT) (Bandura, 1986); and the principles of Social Ecology (SEM) (Bronfenbrenner, 1979), which view the individual (child) within the context of family, school, and community environments that interact interdependently with each other and the individual's (child) behaviour over time to shape their development.

However, in Nigeria, there is a gap in knowledge in the use of gardening as a nutrition education tool to promote healthy eating practices among school-age chidren, which can also be extended to their caregivers. To address the gap, a 4-week garden-enhanced nutrition education programme tagged Kids Nutri-garden™ Vacation School (KNGVS) was designed in the Department of Human Nutrition and Dietetics, University of Ibadan and implemented during the long vacation (throughout the month of August to the second week of September) of primary schools in Nigeria.

The main objective was to promote nutrition knowledge and consumption of traditional vegetables among school-age children. The secondary aim was to provide an evidence-based framework for sustainable low-cost food-systems approach for promoting, integrating, and implementing participatory garden-enhanced nutrition education for school-age children in primary schools in Nigeria.

METHODS

The study used a descriptive pre-post design and included two phases – design (planning) and implementation process; and evaluation. A purposive sample of twenty-seven (n=27) primary school children, 6 – 11 years old, who registered for the 4-week KNGVS programme, and whose parents gave consent, participated in the study. An online self-administered survey questionnaire was circulated calling for participation in the vacation school programme. Parents with children 6-11 years who indicated interest to register their child(ren) for the programme and completed the questionnaire prior to the commencement of the vacation school programme were included. Demographic information were also obtained through the online survey, including their expectations from the programme.

PLANNING PHASE

CURRICULUM

The curriculum content was developed based on an adapted garden-based nutrition education curriculum (Morris et. al. 2002) to suit the cultural context, and age; additional resources relevant to linking nutrition, gardening, cooking and health were obtained from the literature to enrich the content for the various lesson plans and activities (Morris et. al. 2002; Napier and Oldewage-Theron, 2008; Ecoliteracy 2009). A weekly schedule of activities was designed from the curriculum (supplemetary material – Table S1).

The curriculum outline and content were reviewed by experts in human nutrition and dietetics, early childhood development, pedagogy, health promotion and education, agronomy, horticulture, environmental biology, and educational psychology. This expert review helped to refine some of the themes in the curriculum and better contextualise them to achieve learning objectives and outcomes by making suggestions for inclusions, revisions and/or exclusions, and clarification for any misunderstood concept.

The programme components included nutrition education and promotion through hands-on vegetable gardening and cooking, a weekly family newsletter which summarised key nutrition and gardening concepts taught during the week, a recipe for the week, and related activities for practice, community engagement, and interdisciplinary and organisational partnerships (Figure 1). The programme components and its link to the tenets of the SCT and SEM are included in supplementary material -Table S2.

Figure 1. Kids Nutri-garden™ vacation school component diagram

INTERDISCIPLINARY STAKEHOLDER SUPPORT

Letters to request support were written to the university of Ibadan teaching and research farm (UITRF) (for gardening space), Center for Entrepreneurship and Innovation (for publicity), National Horticultural Research Institute (for vegetable seeds), among others. (Stakeholders' roles are included in supplementary material-Table S3.) The letters explained the goal of KNGVS and role(s) the research team wanted them to play in support of the programme. Thereafter face-to-face meetings were held to further the discussions about their roles.

TRAINING OF RESEARCH ASSISTANTS

Ten research assistants were recruited from among undergraduate and postgraduate students of the Department of Human Nutrition and Dietetics, University of Ibadan. They were trained on facilitation of the different activities based on the curriculum which included: data collection, gardening, food demonstration/kitchen activities, preparation of lesson plans and assessment instruments.

IMPLEMENTATION PHASE

Each daily educational session was 180 minutes, for a total of 60 hours during the four-week implementation phase. There were 10 lessons which included classroom time (one day a week), out-door gardening (two days a week), food demonstration and cooking (one day a week), and sports time (one day a week), scheduled from Monday to Friday. The nutrition education and kitchen sessions were conducted by the research assistants. The hands-on gardening sessions were conducted by an experienced gardener from UITRF. The sports session was handled by a coach from the University of Ibadan Sports Council. All the activities were monitored by the principal investigator and co-investigator.

1. GARDENING**:** A conducive 20x20m outdoor space for children to garden safely and for easy access to water was set up at the UITRF. Hands-on gardening activities were progressive from vegetable bed preparation, planting, weeding, watering, and harvesting the vegetables. Four commonly consumed local green leafy vegetables, which could be cultivated and harvested within a four to six-week period were grown: *efotete* (*Amaranthus hybridus)*, *soko* (*Celosia argentea)*, *ugu* (*Telfairia occidentalis)* and *ewedu (Cochorus olitorius).* A teachers' garden plot with the same vegetables was planted one week earlier to have some vegetables ready for identification and to use for food demonstration activities.
2. NUTRITION EDUCATION: Ten 60–90 minutes nutrition education sessions with interactive hands-on learning activities were conducted. Thereafter, the children were clustered by age-group (6 – 7 years, 8 – 9 years and 10 – 11 years) for further explanation and engagement with hands-on activities. These group activities were coordinated by the trained assistants. Topics for the lessons (and mode of delivery) were: (1) our body, food and plants – the connection (delivered using charade game); (2) parts of plants we eat (delivered using flash cards); (3) nutrients our body needs (delivered using flash cards); (4) food groups, nutrients and functions (delivered using flash cards and pictorial PowerPoint slides); (5) My healthy plate (charts, pictorial PowerPoint slides, paper plates for each child to draw or paint the content of their plate); (6) eat a rainbow of fibre rich vegetables and fruits; (7) healthy food vs junk food (video viewing); (8) importance of breakfast (pictorial PowerPoint slides and storytelling); (9) hygiene (discussion); and (10) goal setting for healthy eating (role play and a chart for each child to set a healthy eating goal). Details are provided in supplementary material -Table S1.
3. FOOD DEMONSTRATION**:** Activities were carried out once a week for up to 120 minutes (for each contact), depending on the recipe of the week. The food demonstration and cooking sessions were conducted in the dietetic kitchen of the Dept of Human Nutrition and Dietetics, University of Ibadan. One recipe per week was prepared. Discussions of 60–90 minutes in the classroom followed, to link it to nutrition principles/topics: food group of the individual food components that made up the recipe, nutrients they supplied and plant parts. Children worked in small groups during the cooking activities, closely supervised by trained assistants. Snacks and simple meals with recipes that incorporated fresh local vegetables and fruits were prepared (details provided in supplementary material – Table S4): The recipes were (1) watermelon smoothies blended with youghurt; (2) veggie egg sandwiches (three variants preparared with Amranthus, Celosia and Telfaria, respectively. The recipe included eggs and other veggies like tomatoes, scotch bonnet pepper and onions; (3) veggie noodles (three variants preapared with Amranthus, Celosia and Telfaria, respectively. It included other veggies like tomatoes, onion, scotch bonnet pepper and carrots); (4) veggie cakes (two variants: green cake incorparting Amaranthus, and carrot cake). The children carried out all food preparation activities from set-up to clean-up. Hand washing and hygiene lessons were emphasized during the cooking activities.
4. WEEKLY FAMILY NEWSLETTER**:** The weekly newsletter was to extend the learning to the children's families at home. It contained a summary of learning points from

each week's topics on gardening, nutrition education and food demonstration activities. Simple activities such as the recipe for the week, hands-on gardening tips and trivia related to the learning points were also included.

EVALUATION PHASE

QUESTIONNAIRE DEVELOPMENT

Questions for the children and parents, respectively, were selected and adapted from the existing literature with similar constructs of interest (nutrition knowledge and consumption of vegetables and fruits) phrased for ease of understanding of the age-group and also to suit the context and objectives of the programme. Where necessary, additional questions were created when no appropriate sources were available.

BASELINE DATA COLLECTION

A self-administered questionnaire was provided to the children and parents on the first day, before any activity. The components of the questionnaire in addition to demographic data included twenty (20) local vegetables and fruits physically displayed for the children to identify by name and record their responses in a worksheet. A matching game of six questions on nutrients and their functions; six questions on food groups and their functions in the body; six true or false questions to assess the benefits of traditional green leafy vegetables and eleven multiple-choice questions to assess healthy eating were used in knowledge assessment. Vegetable and fruit consumption practices was assessed by asking how often they ate vegetables or fruits every day, whether or not vegetables or fruits was part of their snacks to school, and whether they had vegetable garden at home.

END-LINE DATA COLLECTION AND FOLLOW-UP

During the last week of the programme, an end-line questionnaire was administered to the children only to assess nutrition knowledge, vegetable and fruit consumption practices, and ownership of a garden at home. Follow-up was done three months after the vacation activities were concluded and included the same questions used at baseline and endline. For both parents and children, a section was included to assess consciousness of healthy choices, asking behaviour for vegetables and fruits, preference for vegetable and fruit consumption, and if they had started growing vegetables in their garden.

For parents only, a section assessing their satisfaction with the programme and its influence on the family was included in the follow up questionnaire. This included 18 questions presented under three sub-sections: influence of the programme on the child and programme satisfaction; influence of the family newsletters and the programme on the other members of the family; seven open-ended questions for the parents to provide general comments about the different aspects of the programme and the level of their child's participation and suggestions for improvement.

DATA ANALYSIS

A total of 24 children who completed the baseline questionnaires were included in the statistical analysis. Three additional participants were excluded for not completing the end-line and follow-up questionnaires because they were no longer available at the time of data collection. Data were analysed using Statistical Package for Social Sciences (SPSS) version 23.0 (Chicago, IL). Descriptive statistics (frequencies, percentage means) were used to summarize demographic data, vegetable and fruit consumption practices and preferred recipe. Inferential statistics (one-way ANOVA) were used to determine the change in nutrition knowlegde scores from baseline to follow-up ($\alpha_{0.05}$) based on a mean and standard deviation of the knowledge scores. Open-ended questions were summarized thematically and key points were highlighted.

ETHICS APPROVAL

The study was approved by the Institutional Review Board/ Ethics Committee of University of Ibadan/University College Hospital, Institute of Advanced Medical Research and Training (IAMRAT) (UI/UEC/20/0088).

RESULTS

PARTICIPANTS CHARACTERISTICS AND NUTRITION KNOWLEDGE

Table 1 shows the characteristics of the participants (children and parents).

Table 1. Demographic characteristics

Children (n =24)	
	***n* (%)**
Age (years)	
Mean age	8.6± 2.3
5 – 8	10 (41.7)
9 – 11	14 (58.3)
Sex	
Male	12 (50.0)
Female	12 (50.0)
Ethnic group	
Yoruba	15 (62.5)
Igbo	9 (37.5)
Parents/ caregivers (n=15)	
Variable	***n* (%)**
Mean age (years)	46.2± 8.1
31 – 40	3 (20.0)
41 – 50	10 (66.7)
51 – 60	1 (6.7)
61 – 79	1 (6.7)
Sex	
Male	3 (20.0)
Female	12 (80.0)
Occupation	
Civil servant	7 (58.3)
Business	2 (16.7)
Retiree	1 (8.3)
Project manager	1 (8.3)
Banker	1 (8.3)

Table 2 shows children's knowledge scores. Overall, there was significant difference in knowledge scores between pre-test and pos-test and between pre-test and followup. But no significant difference between post-test and follow-up. Mean knowledge score for the benefit of vegetables, was not significantly different at the three time points.

Table 2. Nutrition knowledge of children participants (n=24)

Participants' nutrition knowledge scores					
	Pre-test	**Post-test**	**Follow-up**	**F-value**	**P-value**
Identification of locally available vegetables and fruits	11.8±4.5[a]	17.7±2.2[b]	16.5±2.3[b]	20.4	**0.00**
Benefits of vegetables	4.7±1.2[a]	5.3±1.0[a]	5.1±0.8[a]	2.0	0.15
Matching of food groups with their functions	2.0±1.1[a]	3.2±1.7[b]	3.1±1.6[b]	4.5	**0.01**
Matching of nutrients with their functions	3.2±2.1[a]	4.0±1.5[a]	4.2±1.6[a]	1.8	0.17
Knowledge of healthy eating	7.0±2.1[a]	7.9±1.4[ab]	8.2±1.4[b]	3.6	**0.03**
Knowledge of what to eat	6.2±1.7[a]	6.1±1.5[a]	7.4±0.7[b]	5.8	**0.01**
Total knowledge scores	39.2±9.1[a]	48.3±6.7[b]	48.9±4.4[b]	13.4	**0.00**

Values are means±standard deviations

Values with the same superscript across the rows are not significantly different at p<0.05

VEGETABLE AND FRUIT CONSUMPTION PRACTICES AND OWNERSHIP OF GARDEN

The vegetable and fruit consumption practices of participating children are presented in Table 3. Among several apparent improvements, at pre-test, only 12.5% of the participants reported daily vegetable consumption while 41.7% reported never eating vegetables daily. This percentage at follow-up was 33.3%.

Table 3. Vegetable and fruit consumption practices of participants and ownership of a garden

	Pre (n=24) N(%)	**Post (n=21) N(%)**	**Follow-up (n=21) N(%)**
Take vegetables to school			
Almost always or always	7 (29.2)	6 (25.0)	7 (29.2)
Sometimes	2 (8.3)	8 (33.3)	8 (33.3)
Almost never or never	15 (62.5)	7 (29.2)	6 (25.0)
Eat vegetables everyday			
Almost always or always	3 (12.5)	5 (20.8)	8 (33.3)
Sometimes	11 (45.8)	12 (50.0)	13 (54.2)
Almost never or never	10 (41.7)	4 (16.7)	0 (0)
Eat fruits every day			
Almost always or always	6 (25.0)	4 (16.7)	11 (45.8)
Sometimes	14 (58.3)	12 (50.0)	9 (37.5)
Almost never or never	4 (16.7)	5 (20.8)	1 (4.2)
Take fruits as part of your snacks			
Almost always or always	3 (12.5)	7 (29.2)	4 (16.7)
Sometimes	15 (62.5)	8 (33.3)	15 (62.5)
Almost never or never	6 (25.0)	6 (25.5)	2 (8.3)
Have a garden at home?			
Yes	14 (58.3)	16 (66.7)	12 (50.0)
No	10 (41.7)	5 (20.8)	9 (37.5)

FOLLOW-UP ON EATING PRACTICES AND BEHAVIOURS

Table 4 shows the children's eating practices and asking behavior. Majority of the parents (71.4%) reported that they had started a garden because of their child's participation in KNGVS and had 58.3% had harvested since completion of the vacation school. Only 28.6% of parents reported that their children always requested that vegetables be added to their meals (which was not so before), while 37.5% of the children reported that they always request the addition of vegetables to their meals having participated in KNGVS programme.

Table 4. Follow-up on eating practices and behaviours (parents and child responses)

	Parent n=14	**Child n=21**
	F(%)	**F(%)**
More conscious of healthy food choices		
Yes, to a great extent	14 (100)	19 (79.2)
Not really sure	0 (0)	2 (8.3)
I don't think so	0(0)	0 (0)
More preference for eating fruits		
Yes, to a great extent	10 (71.4)	18 (75.0)
Not really sure	0 (0)	1 (4.2)
I don't think so	1 (7.1)	0 (0)
Has always liked eating fruits	3 (21.4)	2 (8.3)
More preference for eating vegetables		
Yes, to a great extent	9 (64.3)	10 (41.7)
Not really sure	4 (28.6)	5 (20.8)
I don't think so	0 (0)	3 (12.5)
Has always liked eating vegetables	1 (7.1)	3 (12.5)
Asking for more vegetables to be bought		
Always	8 (57.1)	8 (33.3)
Sometimes	5(53.7)	10 (41.7)
Never	1 (7.1)	3 (12.5)
Asking to add vegetables to meals?		
Always	4 (28.6)	9 (37.5)
Sometimes	10 (71.4)	10 (41.7)
Never	0 (0)	2 (8.3)
Has started a vegetable garden		
Yes	10 (71.4)	11 (45.8)
No	1 (7.1)	4 (16.7)
We already had a garden in our home	3 (21.4)	6 (25.0)
If yes, have you grown and harvested from your garden since completion of KNGVS programme?		
Yes	11 (78.6)	14 (58.3)
No	3 (21.4)	5 (20.8)
Prepared any of the recipes taught?		
Yes	13 (92.9)	21 (87.5)
No	1 (7.1)	0 (0)

FAMILY PARTICIPATION IN ACTIVITIES IN THE WEEKLY FAMILY NEWSLETTER

A majority (83.3% and 91.7%) found the activities easy to carryout and easy to understand, respectively. All parents found the information and activities contained in the newsletter useful and educating (Figure 2).

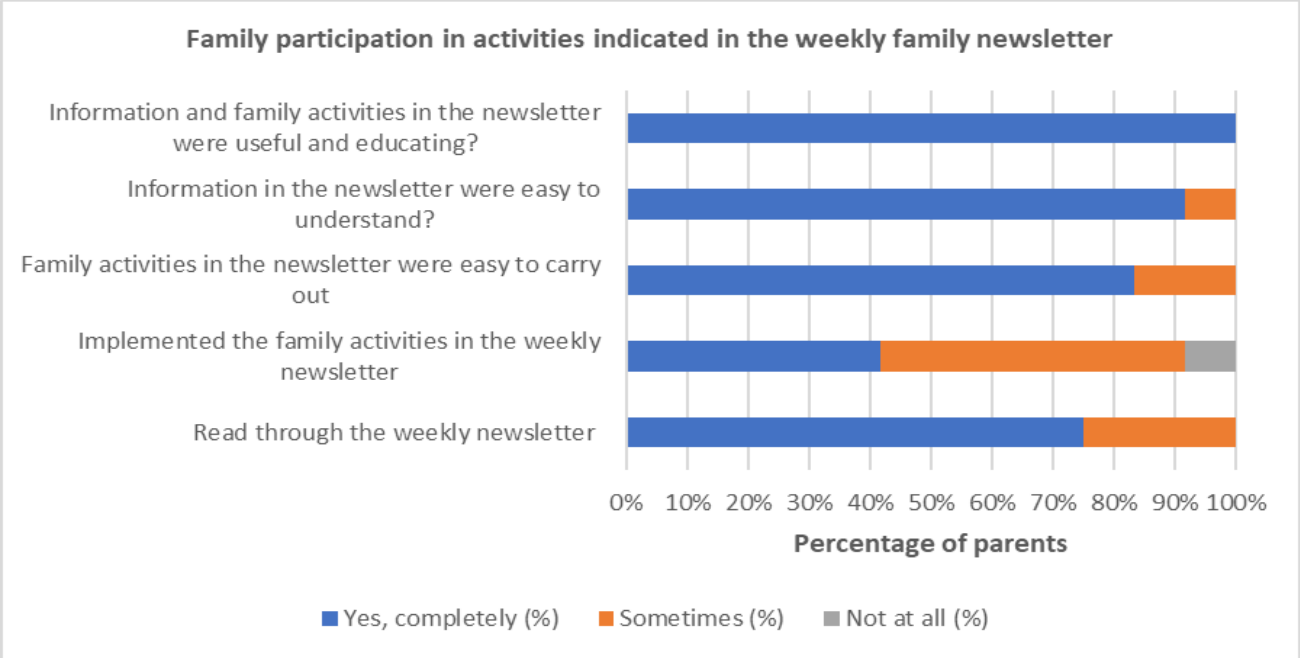

Figure 2. Family participation in activities indicated in the weekly family newsletter

OPEN-ENDED COMMENTS FROM PARENTS ON THEIR PERCEPTION OF THE KNGVS PROGRAMME

GENERAL THOUGHTS AND WHAT THEY LIKED MOST ABOUT KNGVS

I am really glad my kids participated as they were excited to learn about fruits and vegetables, participated in other activities and meeting new friends.'

It has made my kids to be more conscious of healthy food choices.'

'The farm and kitchen experience. Letting the children grow the vegetables, watch them grow and cooking creative dishes every week.'

PERCEPTION OF THEIR CHILD'S EXPERIENCE AT KNGVS

'My daughter enjoyed every bit of it and is now conscious of planting and more interested in vegetables like never before. It has had a good impact on her.'

'She found it a refreshing departure from the routine holiday coaching which is no different from regular schooling.'

'My son was always looking forward to each day at the school and he never stopped to impress his brothers about all the activities he took part in and he tries as much as possible to replicate some of these at home.

"Nutri-garden has added better attitude to their eating as per vegetables and fruits. They can prepare a vegetable bed on their own and plant vegetables which we've just finished eating."

INFLUENCE OF KNGVS ON OTHER FAMILY MEMBERS

'They keep reminding us of eating fruits and vegetables. Although I usually try it in the past, they are more conscious of the content of their food.'

'We have improved on our vegetable intake.'

My child's participation in the programme led to the family starting a vegetable garden.'

USEFULNESS OF THE WEEKLY NEWSLETTER IN EXTENDING THE LEARNING EXPERIENCE OF YOUR CHILD AND INFLUENCING HEALTHYEATING PRACTICES IN YOUR HOME

'Very informative, useful and have formed part of our recipe collection in the family.'

'It helped us to replicate the healthy food and prepared it to the satisfaction of the children.'

DISCUSSION

The KNGVS is a novel programme in Nigeria, using theoretical models of behaviour change and an evidence-based curriculum to develop a comprehensive, garden-enhanced nutrition education programme to promote healthy eating, especially vegetable consumption and lifestyle behaviors in school-age children. It also meets a need in the community for programming during the long school holidays by providing hands-on, engaging education related to topics that are important to parents, as advised by Davis et. al. (2015). The use of this approach has the potential to not only facilitate basic education (including teaching and learning) but also to promote sustainable development across different socio-economic and socio-cultural settings.

To the best of the authors' knowledge, KNGVS is the first published study in Nigeria to employ garden-enhanced nutrition education among school-age children to improve healthy eating choices, particularly during the long holidays of primary schools. The long vacation is still largely used as an opportunity to prepare children for starting their next grade or for studying for examinable subjects commonly referred to as 'coaching lessons', with little or no inclusion of extra-curricular activity (Oyewusi and Orolade, 2014).

Findings from KNGVS programme showed a significant improvement in nutrition knowledge. Similar garden-enhanced education have shown that participating in such a programme significantly improves gardening knowledge, nutrition knowledge, and vegetable preferences (Skelton et.

al. 2020; Kim et. al. 2021). Involvement of the children in the process of cultivating local vegetables, harvesting, and cooking the vegetables was observed to be effective in increasing their ability to identify local vegetables, asking for vegetables and also consumption, as observed by previous studies (Skelton et. al. 2020; Kim et. al. 2021; Leuven et. al. 2018).

Children's nutrition is a top public health concern, hence the need to shape their dietary habits early. KNGVS falls within the purview of innovative actions itemized in the independent food systems dialogue, which focus on improving child nutrition in Nigeria through food systems actions captured in discussion topic 4 which is "to improve nutrition education and behavioural change programmes to enable children to learn and adopt healthy dietary habits" (Choices International Foundation).

To further reinforce healthy dietary behaviour, the children were taught to prepare healthier versions of similar foods consumed at home by incorporating local vegetables obtained from the nutri-garden they planted. Specifically, this centered on using frequently consumed and favorite foods of children in Nigeria, such as noodles, sweet potatoes, and eggs. Studies have shown that culinary nutrition education can also drive behaviour change (Fredericks et. al. 2020).

Previous studies evaluating the relationship between nutrition knowledge and dietary intake have established that knowledge greatly impacts dietary intake such that the higher the nutrition knowledge, the better the attitudes and dietary practices (Asakura et. al. 2017, Spronk et. al. 2014). Parents in the current study attested to the fact that the increase in the children's knowledge accompanied a positive influence on the family and improved their vegetable consumption. The availability of the weekly family newsletter may have also contributed, because parents reported that their children often insisted on their participation in the family activities proposed. Some studies have highlighted the importance of parental involvement in fostering the effect of nutrition education interventions focused on dietary change (Scherr et. al. 2017).

Further, while the duration of KNGVS was only four weeks, the time intensive nature, approximately 20 hours per week, benefitted the children's learning for both knowledge and practice (Contento et. al. 1992). Young children also gained life-long skills from garden-enhanced nutrition education. This approach is one commonly called for, but KNGVS's novelty includes that it is specific to school-age children and local vegetables commonly cultivated and consumed in Nigeria were focused on.

Generally, programmes that utilize school gardens demonstrate success in improving dietary intakes of children. However, they often face sustainability challenges such as funding, garden maintenance, availability of teacher(s) to be in-charge, leading to discontinuation (Davies et. al. 2015, Akinyemi et. al. 2009). As a programme implemented outside the regular school setting and curriculum, KNGVS proactively tried to address some of these challenges with the following strategies: leverage support and collaboration from different stakeholders; utilise an online crowd-funding mechanism for financial support; involve family and community to reinforce knowledge and practice of good nutrition at the household level and beyond the vacation school period.

Notwithstanding the stated challenges of garden sustainability, the programme was successfully implemented. KNGVS framework is a promising food-system targeted initiative that provides a window of opportunity for influencing and driving healthy eating behaviour among school-age children in Nigeria. The framework leverages hands-on learning to give the children first-hand experience on the dynamics and linkages between nutrition, health, agriculture and the environment at different levels of social interaction. More so, it contributes to the National School Health Policy in Nigeria that aims to provide nutrition education and participatory learning experiences for the development of knowledge, attitudes, skills and desirable habits including dietary habits in relation to personal and community health.

STRENGTHS AND LIMITATIONS

A major strength of KNGVS intervention design is its foundation in theoretical models (SEM and SCT) of behaviour change. The programme promotes changes to eating behaviours, with emphasis on hands-on experiences (vegetable gardening and healthy cooking), with trained research assistants to deliver the intervention, and demonstrate community engagement through partnerships with local stakeholders. These are hallmarks of successful nutrition education interventions and provide saturation at multiple levels of the model.

Use of a very small convenience sample of participants already committed to attending KNGVS programme with no control group may reduce the generalization of the findings. The study was based on self-reports which can lead to social desirability bias. This study covered only a period of four weeks and thus we do not know the extent to which the changes identified were sustainable.

CONCLUSION

Garden-enhanced nutrition education including strategies such as food demonstration and parental involvement can positively influence knowledge, preference and consumption of vegetables among school-age children.

AUTHOR CONTRIBUTIONS

SIE – conceptualisation, methodology; SIE, IB, AO – investigation; SIE, IB, OA -data curation; IB, MAG, RES- writing (original draft); SIE, IB, MAG, RES- writing (review and editing); SIE – supervision; SIE and IB – Project administration; SIE and AO – Resources.

CONFLICT OF INTEREST

The authors declare that they have no other potential conflicts of interest.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN SCIENTIFIC WRITING

Nothing to disclose

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REFERENCES

Akinyemi, O.M., von Fragstein, P. and Agnew, D. (2009). 'The State of School Gardening Programs in Sustainable Development in Nigeria', *The International Journal of Learning*: *Annual Review,* 15(10), 231–246. https://doi.org/10.18848/1447-9494/cgp/v15i10/45990

Asakura, K., Todoriki, H. and Sasaki, S. (2017) 'Relationship between nutrition knowledge and dietary intake among primary school children in Japan: Combined effect of children's and their guardians' knowledge', *Journal Of Epidemiology*, 27(10), 483–491. https://doi.org/10.1016/j.je.2016.09.014.

Bandura, A. (1986) Social foundations of thought and action: A social cognitive theory., *APA Psycnet*. Available at: https://psycnet.apa.org/record/1985-98423-000.

Bronfenbrenner, U. (1979) 'The ecology of human development: Experiments by nature and design', *JSTOR* Daily. Available at: https://www.jstor.org/stable/j.ctv26071r6.

Choices International Foundation in partnership with United Nations Children's Fund, Global Alliance for Improved Nutrition, Partnership for Child Development and Nigerian Heart Foundation. 2021. Independent Food systems dialogue on improving child nutrition in Nigeria (discussion topic 4). Dialogue event page: https://summitdialogues.org/dialogue/13010/

Contento, I.R., Manning, A.D. and Shannon, B. (1992) 'Research perspective on school-based nutrition education', *Journal of Nutrition Education*, 24(5), 247–260. https://doi.org/10.1016/s0022-3182(12)81240-4.

Davis, J.N., Nikah, K., Landry, M.J., Vandyousefi, S., Ghaddar, R., Jeans, M., Cooper, M.H., Martin, B., Waugh, L., Sharma, S.V. and van den Berg, A.E. (2022) 'Effects of a school-based garden program on academic performance: A cluster randomized controlled trial', *Journal of the Academy of Nutrition and Dietetics,* 0(0). https://doi.org/10.1016/j.jand.2022.08.125.

Davis, J.N., Spaniol, M.R. and Somerset, S. (2015) 'Sustenance and sustainability: maximizing the impact of school gardens on health outcomes', *Public Health Nutrition*, 18(13), 2358–2367. https://doi.org/10.1017/s1368980015000221.

Ecoliteracy (2009). Getting Started, A Guide for Creating School Gardens as Outdoor Classrooms . Available at: https://www.ecoliteracy.org/sites/default/files/uploads/getting-started-2009.pdf.

Fredericks, L., Koch, P. A., Liu, A., Galitzdorfer, L., Costa, A., and Utter, J. (2020) 'Experiential features of culinary nutrition education that drive behavior change: frameworks for research and practice', *Health Promotion Practice*, 21(3), 331–335. https://doi.org/10.1177/1524839919896787.

Harika, R., Faber, M., Samuel, F., Kimiywe, J., Mulugeta, A., & Eilander, A. (2017) 'Micronutrient status and dietary intake of iron, vitamin A, iodine, folate and zinc in women of reproductive age and pregnant women in Ethiopia, Kenya, Nigeria and South Africa: A systematic review of data from 2005 to 2015', *Nutrients*, 9(10), 1096. https://doi.org/10.3390/nu9101096.

Heim, S., Stang, J. and Ireland, M. (2009) 'A garden pilot project enhances fruit and vegetable consumption among children', *Journal of the American Dietetic Association*, 109(7), 1220–1226. https://doi.org/10.1016/j.jada.2009.04.009.

Kim, H.-R., Kim, S. and Park, S.-A. (2021) 'The effects of horticultural activity program on vegetable preference of elementary school students', *International Journal of Environmental Research and Public Health*, 18(15), 8100–8100. https://doi.org/10.3390/ijerph18158100.

Langellotto, G.A. and Gupta, A. (2012) 'Gardening increases vegetable consumption in school-aged children: A meta-analytical synthesis', HortTechnology, 22(4), 430–445. https://doi.org/10.21273/horttech.22.4.430.

Leuven, J. R., Rutenfrans, A. H., Dolfing, A. G., & Leuven, R. S. (2018) 'School gardening increases knowledge of primary school children on edible plants and preference for vegetables', Food Science & Nutrition, 6(7), 1960–1967. https://doi.org/10.1002/fsn3.758.

Morgan, P. J., Warren, J. M., Lubans, D. R., Saunders, K. L., Quick, G. I., & Collins, C. E. (2010) 'The impact of nutrition education with and without a school garden on knowledge, vegetable intake and preferences and quality of school life among primary-school students', *Public Health Nutrition*, 13(11), 1931–1940. https://doi.org/10.1017/s1368980010000959.

Morris, J. L., Koumjian, K. L., Briggs, M., and Zidenberg-Cherr, S. (2002) 'Nutrition to grow on: a garden-enhanced nutrition education curriculum for upper-elementary schoolchildren', *Journal of Nutrition Education and Behavior*, 34(3), 175–176. https://doi.org/10.1016/s1499-4046(06)60088-2.

Napier C. E., and Oldewage-Theron W. H (2008). Food Based dietary guidelines activity book, primary school children. Institute of Sustainable Livelihoods, Vaal University of Technology. South Africa 2008.

Oldewage-Theron, W. and Egal, A. (2010) 'Nutrition knowledge and nutritional status of primary school children in QwaQwa', *South African Journal of Clinical Nutrition,* 23(3), 149–154. https://doi.org/10.1080/16070658.2010.11734329.

Oyewusi, L.M. and Orolade, K.S. (2014) 'Private tutoring boom in Nigeria: An investigation into the emerging but controversial learning space', *Journal of Educational and Social Research* [Preprint]. https://doi.org/10.5901/jesr.2014.v4n6p271.

Parmer, S. M., Salisbury-Glennon, J., Shannon, D., and Struempler, B. (2009) 'School gardens: An experiential learning approach for a nutrition education program to increase fruit and vegetable knowledge, preference, and consumption among second-grade students', *Journal of Nutrition Education and Behavior*, 41(3), 212–217. https://doi.org/10.1016/j.jneb.2008.06.002.

Sanusi, R.A., Wang, D., Ariyo, O., Eyinla, T.E., Tassy, M., Eldridge, A.L., Ogundero, A., Leshi, O., Lenighan, Y.M., Ejoh, S.I. and Aleru, E., (2022). Food sources of key nutrients, meal and dietary patterns among children aged 4–13 years in Ibadan, Nigeria: findings from the 2019 kids nutrition and health study. *Nutrients*, 14(1), p.200

Scherr, R.E., Linnell, J.D., Dharmar, M., Beccarelli, L.M., Bergman, J.J., Briggs, M., Brian, K.M., Feenstra, G., Hillhouse, J.C., Keen, C.L. and Ontai, L.L., (2017) 'A

multicomponent, school-based intervention, the shaping healthy choices program, improves nutrition-related outcomes', *Journal of Nutrition Education and Behavior*, 49(5), 368-379.e1. https://doi.org/10.1016/j.jneb.2016.12.007.

Skelton, K. R., Lowe, C., Zaltz, D. A., & Benjamin-Neelon, S. E. (2020). Garden-based interventions and early childhood health: an umbrella review. *International Journal of Behavioral Nutrition and Physical Activity*, 17, 1-19.

Somerset, S. and Markwell, K. (2009) 'Impact of a school-based food garden on attitudes and identification skills regarding vegetables and fruit: a 12-month intervention trial', *Public Health Nutrition,* 12(2), 214–221. https://doi.org/10.1017/s1368980008003327

Spronk, I., Kullen, C., Burdon, C., and O'Connor, H. (2014) 'Relationship between nutrition knowledge and dietary intake', *British Journal of Nutrition*, 111(10), 1713–1726. https://doi.org/10.1017/s0007114514000087.

Storz, M.A. and Heymann, E.P. (2017) 'School gardening: A different approach to tackle childhood obesity?', 94(2), 54–55. Available at: **Full text here**

World Health Organization, Noncommunicable diseases country profiles 2018. 2018. **Full text here**

Yoder, A. B. B., Liebhart, J. L., McCarty, D. J., Meinen, A., Schoeller, D., Vargas, C., and LaRowe, T. (2014) 'Farm to elementary school programming increases access to fruits and vegetables and increases their consumption among those with low intake', *Journal of Nutrition Education and Behavior*, 46(5), 341–349. https://doi.org/10.1016/j.jneb.2014.04.297.

SUPPLEMENTARY MATERIAL

Table S1: Summary of curriculum and weekly schedule of activities during Kids Nutri-garden™ vacation school

Activities	**Nutrition education**	**Nutri-garden**	**Nutri-sports**	**Nutri-garden**	**Nutri-kitchen**
Location	**In-door classroom**	**Out-door garden**	**Outdoor sports**	**Out-door garden**	**In-door kitchen**
	Lessons on nutrition education using different interactive methods – hands-on team activities, flashcards, charades, videos, and PowerPoint presentations	**Lessons on gardening and hands-on activities in the Nutri-garden** **In-door nutrition education lesson to link the garden activity of the day**	**Sports activities with the sports coaches** **In-door nutrition education lessons continued after outdoor sports**	**Lessons on gardening and hands-on activities in the Nutri-garden** **In-door nutrition education lesson to link the garden activity of the day**	**Weekend family activity: family newsletter-001** (summary of week's activity and family task – crossword puzzle, home practice of recipe of week, and gardening activities of the week)
	Daily F&V charting and Daily snack documentation				
	Daily Reflection on previous day's learning experience				
	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**
Week 1	**Opening and registration- Introductory activities**: **Nutri-Edu Lesson 1: Our Body, food, and Plants – the connection between Nutrition and Gardening**	**Nutri-garden Lesson 1** – introductory garden visit: garden tools, land preparation, making veggie beds	**Sports activity1: Warm-up and stretch activities** **Nutri-edu Lesson 2: Parts of plants we eat**	**Nutri-garden lesson 2**: manuring, planting, and watering Allocation of veggie beds to kids	**Recipe of the week: Watermelon smoothie** Activity after kitchen: tasting and recap the parts of plants we eat
Week 2	**National Public holiday**		**Nutri-edu Lesson 3 -** Nutrients our body needs	**Nutri-garden lesson 3:** Care of our growing veggies, and weeds (weeding our garden and watering, observing growing plants) **Nutri-edu lesson 4:** food groups and nutrients and functions	**Nutri-cook day**: Applying the food group and nutrient principle **Recipe of the week: Veggie egg sandwiches** **Activity after cooking**: Identifying the food groups, nutrients and functions of the prepared recipe.
Week 3	**Nutri-edu lesson 5: Healthy eating series** - MyPlate and food groups	**Nutri-garden Lesson 4 -** garden insects, friends or foes Nurturing our veggies **Nutri-edu lesson 6: Healthy Eating series** Eat a rainbow (F&V consumption and importance)	**Excursion to creative eco-garden Moniya, Ibadan** **Lesson: reducing, recycling, reusing, and upcycling waste materials for gardening use and handcrafts** **Organic compost making** **Games: treasure hunt in the garden**	**Nutri-garden lesson 5:** thinning, weeding, and watering – checking on our plants **Nutri-edu Lesson 7- healthy eating series** -staying physically active - consequences of poor vs healthy food choices to the body **Video: healthy food vs junk food– healthy food choices**	**Nutri-cook day**-making healthy meals **Recipe of the week: Veggie noodles** **Activity after cooking**: Identifying the food groups, nutrients, and functions of the prepared recipe
Week 4	**Nutri-edu lesson 8: healthy eating series** Breakfast importance Water drinking vs sweetened beverages	**Nutri-garden lesson 6:** Nurturing vegetables- Art in the garden - lessons from the eco-creative garden excursion **Nutri- edu lesson 9: Hygiene:** Importance of washing hands	**Sports activity: Visit to the gym** **Nutri-edu lesson 10:** Goal setting	**Nutri-garden lesson 7:** Preparation for harvesting/ **Revision of all lessons***	**Nutri-cook day – making healthy snacks.** **Recipe of the week:** 1. veggie cake and green smoothies and creative fruit decorations 2. Green smoothies (using veggies from our Nutri-garden)

					Activity after cooking Identifying the food groups, nutrients, and functions of the prepared recipe
Week 5 (exhibition)	Presentation of teamwork - poetry/song/dance/drama on healthy eating and gardening for exhibition Post-assessment activities	Kids Nutri-garden™ exhibition day and closing ceremonies			

Table S2. Social cognitive theory and socio-ecological theory as applied to the kids' Nutri-garden™ vacation school program component

Component	Activities	Assessments	Tenets of SCT/SEM
Nutrition education and health promotion	Nutri-edu curriculum Healthy cooking/food demonstration Hands-on vegetable gardening Daily F&V tracking Daily snack tracking Physical activity/sports	Child survey; Nutrition knowledge assessment Healthy life style assessment F&V assessment Snack food assessment Program assessment	**Individual and inter personal factors:** Knowledge Skills Behavior Reinforcement
Family and community engagement	Nutri-garden family newsletter Kids Nutri-garden food and fun fair/exhibition	Parent survey: Program assessment Volunteer feedback survey	**Environmental factors** Reinforcements
Interdisciplinary and organizational partnerships/collaboration	Supply of seeds for planting, providing garden space and agricultural expertise, environmental sensitization on waste upcycling, promotion and support of the program	-	**Environmental factors and socio-cultural values** that act interdependently to support and sustain the program components

Table S3. Interdisciplinary and organizational partnerships and their roles in Kids Nutri-garden™ Vacation School program

S/N	Stakeholder/Collaborators/partners within and outside the university of Ibadan	Role
1	Department of Human Nutrition and Dietetics	Provision of indoor classroom space and kitchen facilities
2	Resource person from Department Crop protection and environmental biology	Facilitated a session with the children on garden pests (friends or foes),
3	Teaching and Research farm crop unit (TRF)	Provided a children friendly garden space where all gardening activities took place and a gardener to teach the children
4	Sports council	Facilitated the sports activities/sessions for the children
5	Centre for Entrepreneurship and Innovation (CEI)	Produced publicity materials to promote the programme.
6	National Institute for Horticultural Research and Training (NIHORT)	Donated some of the vegetable seeds that were planted by the children
7	Africa eco-creative hub	Conducted a session for the children during their excursion visit to the waste museum on environmental protection through converting 'waste materials to useful items for planting in the garden and compost making from organic food materials.
8	Dufil Foods	Supplied noodles products for one of the food demonstration sessions, which was used to teach the children how to prepare a healthy and nutritious noodles recipe with local green leafy vegetables grown in the nutri-garden.
9	givingharbour.com	Online fundraising platform through which funds were raised publicly for the program
10	Behealthy Africa	Support and promotion of the programme

Table S4. KNGVS vegetable and fruit recipes

Recipe type	**Fruit/ local leafy vegetable used**
Smoothie	Watermelon
Veggie egg sandwiches	*Amaranthus sp, Celosia sp* and *Telfaria* (harvested from the nutri-garden), used respectively
Veggie noodles	*Amaranthus sp, Celosia sp* and *Telfairia occidentalis* (harvested from the nutri-garden), used respectively
Veggie cakes	Carrots and *Amaranthus* leaves