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Impacts of Aquaponics Gardening on Weight Management of Undernourished Children

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ABSTRACT
Background: Malnutrition remains a major concern among children in disadvantaged communities in the Philippines. This study examined the effectiveness of aquaponics gardening in supporting weight management and promoting healthy eating among undernourished children. **Methods:** A quasi-experimental pre-test–post-test design was implemented with 30 children aged 6–12 years in Bocaue, Bulacan, identified as undernourished (BMI-for-age < 5th percentile). Over eight weeks, subjects engaged in aquaponics gardening, nutrition education, and meal preparation using harvested produce. Data were gathered through BMI measurements, a validated Likert-scale survey, and 24-hour dietary recalls. Paired t-tests evaluated pre- and post-intervention changes. **Results:** Significant improvements were observed in weight (23.4 kg to 25.1 kg) and BMI (13.5 to 14.3) ($p < 0.001$). Subjects also demonstrated greater nutritional knowledge, more positive perceptions of vegetables, and healthier eating behaviors, including increased vegetable intake. **Conclusion:** Aquaponics gardening is a feasible, sustainable approach to improving child nutrition and dietary habits. Its hands-on design fosters learning and self-efficacy, supporting long-term food security and health promotion in low-resource communities.

KEYWORDS
Aquaponics, Children, Experiential learning, Malnutrition, Weight management

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1. BACKGROUND

Millions of individuals worldwide are impacted by economic inequality, as 8.5% of people live on less than $2.15 each day (World Bank, 2024). This economic issue often leads to challenges particularly problems with food security, leading to decreased consumption of adequate nutrients especially on children which then leads to malnutrition.

The World Health Organization (WHO, 2024) classified three types of malnutrition which includes undernutrition, overweight, and micronutrient-related nutrition. Undernutrition was further subdivided into wasting, stunting and underweight. By 2023, undernutrition had become a growing concern, with 700 million of people or 9.2% of the global population was affected. This represents a total of 122 million people more than the census recorded in the year 2019 mostly because of the COVID-19 outbreak. Countries with high food insecurity experienced the most significant impact. Asia saw a decrease from 8.8% to 8.5%, although these numbers remained higher than pre-pandemic levels. For 2030, estimation of about 600 million people being chronically malnourished is expected, and this has been caused by the pandemic (Bhupathiraju & Hu, 2023).

Reflecting these global trends, the Philippines faces significant nutritional challenges. Filipinos eat an average of 58 grams of vegetables and 17 grams of fruit per day, which is significantly less than the 400 grams recommended by the WHO and the Food and Agriculture Organization of the United Nations (FAO), according to the 2021 Expanded National Nutrition Survey (ENNS) conducted by DOST-FNRI (Quetua, 2024). This low level of vegetable consumption contributes significantly to undernutrition, increasing the prevalence of stunting, wasting, and underweight among children. The 2018-2019 ENNS revealed that 24.2% of Filipino children aged five to 10 were undernourished, with higher rates in boys (25.8%) than girls (22.5%), and more prevalent in rural areas (26.6%) than urban regions (20.9%) (Arias et al., 2024).

Despite ongoing efforts, many low-income families struggle to afford nutritious food, often relying on cheap, processed options high in sugar, salt, and fats. This contributes to severe malnutrition in low-income countries, with processed foods being more accessible than healthier alternatives (UNICEF, 2024). As a result, many children lack the nourishment needed for proper growth. Addressing this issue is essential to achieving Sustainable Development Goals, particularly SDG 2 (Zero Hunger) and SDG 3 (Good Health and Well-being) (WHO, 2024).

In the Philippine setting, undernutrition remains especially prevalent in rural areas, where access to fresh, affordable produce is limited and dietary habits are shaped by economic constraints (Nazario, 2022). Bocaue, Bulacan reflects many of these challenges. The selected barangays are home to families experiencing food insecurity, often relying on processed foods due to cost and availability. While formal data specific to these communities are limited, the researchers observed nutritional patterns consistent with national trends, including low vegetable intake and signs of underweight among children. This context made Bocaue a meaningful site for exploring aquaponics gardening as a sustainable intervention.

Addressing nutritional gaps requires sustainable solutions like aquaponics, a system combining aquaculture and hydroponics to produce chemical-free vegetables and fish while using 90% less water (Garnida, 2023). Aquaponics has been shown to improve food access (Klimas et al., 2021), support food security (Obirikorang et al., 2021), and yield nutrient-rich crops (Enoki et al., 2025). However, most studies focus on system efficiency rather than its effects on nutrition.

Community gardening has been linked to improved dietary habits and food literacy in children (Soward et al., 2023). However, few studies have combined aquaponics with structured nutrition education to examine its effects on the health of undernourished children. While aquaponics is recognized for its environmental benefits (e.g., water conservation, space use), its direct impact on children's nutrition remains underexplored (Kluezkovski et al., 2024), with most research focusing on technical outcomes.

Considering the broad impact of malnutrition, nurses have an opportunity to lead community-based nutrition interventions. As frontline professionals, nurses are in the position to assess, educate, and empower underserved families using sustainable, evidence-based models. Their holistic practice and trusted presence make them ideal advocates for initiatives like aquaponics gardening. Framing this study within nursing practice highlights the profession's potential to promote health equity and improve child nutrition.

This study evaluates the impact of an aquaponics gardening intervention on vegetable intake, nutritional knowledge, perception, and healthy eating behaviors among undernourished Filipino children. Grounded in Bandura's Social Cognitive Theory, it uses experiential learning, modeling, and self-efficacy to promote dietary change (Rumjaun & Narod, 2020; LaMorte, 2022). The study aims to fill a critical gap by offering evidence for aquaponics as a practical, child-focused nutrition strategy.

2. METHODS

A quasi-experimental pre-test–post-test design was used to assess the intervention's effectiveness without

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randomization or control groups (Elder, 2023). This design ensured all subjects received the potentially beneficial program while allowing comparison of outcomes before and after implementation.

The study was conducted in Bocaue, Bulacan, specifically at Ark of Noah GK Village, Barangay Taal, and P. Lazaro Street (Sitio Bihunan), Biñang 2nd. These locations were selected based on accessibility and logistical feasibility.

Subjects were Filipino children aged 6 to 12 with a BMI below the 5th percentile, from low-income households earning under PhP13,873 per month, without chronic illness or regular supplement intake, and with parental consent for participation. This age range reflects a key developmental stage for shaping food preferences (Villa, 2021), and income criteria align with the national poverty threshold (PSA, 2023). Diets remained consistent throughout to ensure validity.

Participants were selected based on homogeneity in nutritional status, ensuring that all recruited children met the study criteria for undernutrition. This approach facilitated efficient data collection and enhanced the relevance of findings to the target population. A minimum of 30 subjects was set based on the Central Limit Theorem to support parametric testing and enhance result reliability (Ganti, 2024).

All children were assessed before and after the eight-week intervention using three tools: BMI-for-age z-scores, a two-day 24-hour dietary recall, and a validated survey questionnaire developed with expert guidance. The survey, translated using back-translation, covered demographics, knowledge, behaviors, and perceptions, and underwent reliability testing, yielding a Cronbach's alpha of 0.74 which indicates acceptable internal consistency. Items 5 and 12 were excluded from the instrument, as their inclusion resulted in a lower Cronbach's alpha score, indicating poor internal consistency, as well as Item 19 due to repetition of questions with item 16. BMI was calculated using an online tool and interpreted via WHO charts. The dietary recall, adapted from King's College London, was completed with parental assistance to evaluate vegetable intake (DAPA, n.d.).

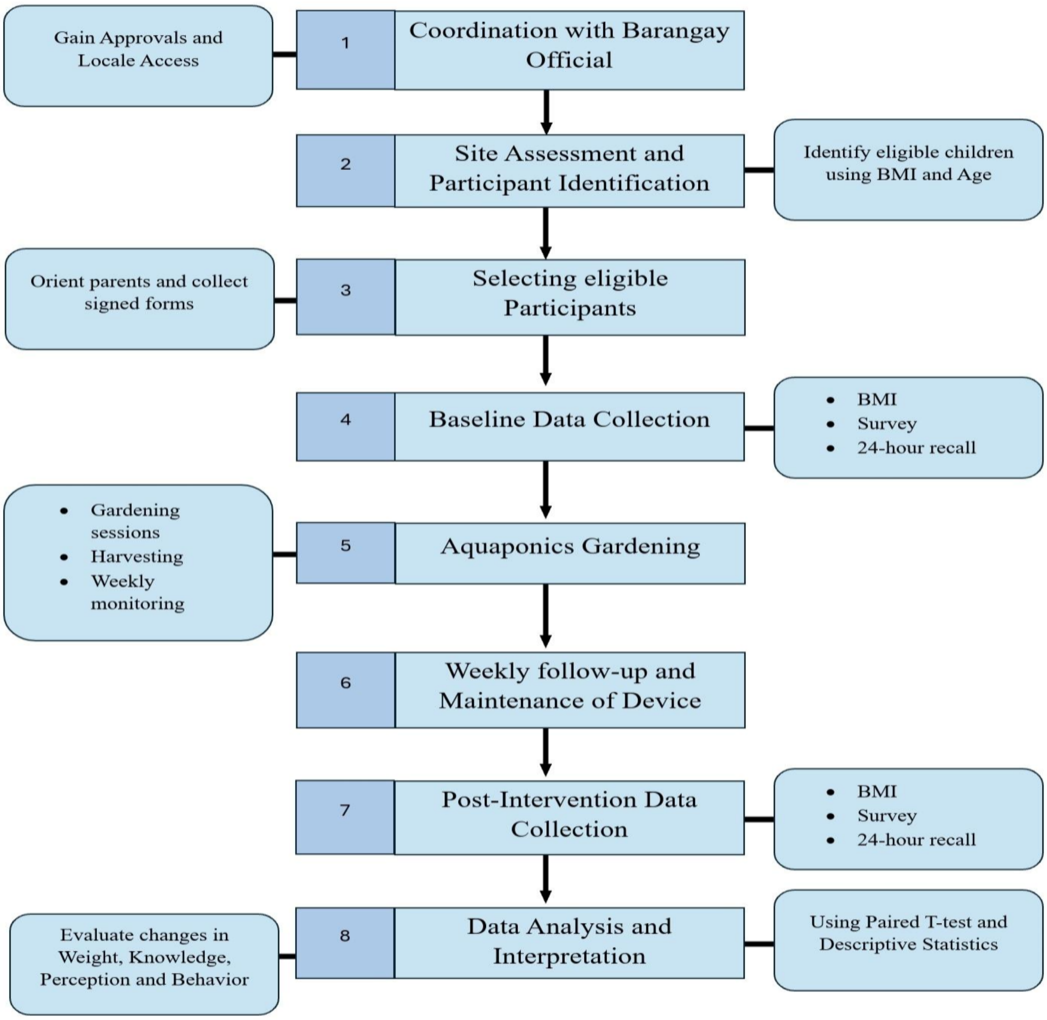

Figure 1. Data Gathering Procedure

To assess the effectiveness of aquaponics gardening in improving the weight status and nutritional behaviors of undernourished children, a structured and ethically guided data gathering protocol was established (Figure 1). This protocol combined device establishment, anthropometric assessment, dietary monitoring, and educational interventions within a three-month period.

The research began with formal coordination with barangay officials in Bocaue, Bulacan, specifically in Barangay Taal and Sitio Bihunan, Biñang 2nd. A formal request for cooperation was submitted and approved, enabling the researchers to assess the suitability of the area and to identify potential subjects. Given the nature of aquaponics systems, coordination was also done to secure a stable electricity supply necessary for operating the water filtration and pump systems.

Upon securing approval, baseline screening started in January. Height and weight measurements were obtained from children aged six to twelve years who were identified as undernourished, having a Body Mass Index (BMI) below the 5th percentile. After preliminary screening, informed consent forms were distributed and approved by the child's parent or legal guardian. These forms outlined the objectives of the study, its benefits and risks, and the voluntary nature of participation.

Prior to the intervention, baseline data were collected through anthropometric assessments, validated survey questionnaires on nutrition knowledge and eating behaviors, and a two-day 24-hour dietary recall assisted by parents. However, due to unforeseen delays in the final validation and translation of these instruments, ensuring linguistic clarity and psychometric reliability, the pretest survey and dietary recall were administered later than originally scheduled. Although these tools were designed and finalized with the assistance of experts, the timeline for validation extended closer to the start of the intervention, compelling the researchers to proceed with the gardening sessions on the originally planned start date to avoid delaying the overall project. Moreover, a food preparation guide was also provided to the subjects' parents. This guide aimed to promote the consumption of vegetables, specifically pechay (Brassica rapa) and mustasa (Brassica juncea), the only vegetables utilized in the study. Recipes included culturally relevant and nutritionally beneficial dishes such as Ginisang Pechay and Mustasa, Sinigang, Tofu with Pechay and Mustasa, and Sardines with Pechay. This ensured that the children were not only exposed to aquaponics gardening but also given opportunities to regularly consume the harvested vegetables in familiar and appealing meals at home.

The aquaponics system was then installed in a central, accessible community location. The setup involved assembling a fish tank, filtration units, and grow beds, with Tilapia (Oreochromis niloticus) as the fish species supporting the nutrient cycle. Pechay and mustasa seeds were germinated using sterilized coco peat as the growing medium, and seedlings were transferred to the system once sufficiently developed. Gardening kits and instructions were provided to the children, who were taught how to tend the garden with the guidance of the researchers.

The intervention spanned eight weeks, during which subjects engaged in hands-on gardening sessions, received basic agricultural education, and attended nutrition classes designed for both children and their parents. These sessions reinforced healthy eating behaviors and increased awareness of the nutritional value of vegetables. Parents played an integral role by preparing meals based on the food preparation sheet, further supporting their children's dietary transformation.

Throughout the intervention, weekly follow-ups were conducted to monitor the functionality of the aquaponics system and the progress of both plant and fish development. Children's engagement was observed, and ongoing mentoring was provided to sustain their interest and participation.

After the intervention, the same data collection tools were administered during the post-assessment phase in April. Weight, height, and BMI were re-measured, while updated survey responses and dietary recalls were gathered to determine changes in nutritional knowledge, perceptions, behaviors, and vegetable consumption frequency. These post-intervention metrics were analyzed and compared to the baseline data to evaluate the impact of aquaponics gardening on the subject nutritional status.

This protocol ensured that all aspects of the data gathering process were methodical, ethical, and community centered. It highlights not only the quantitative outcomes of the intervention but also its educational and behavioral dimensions, acknowledging the significant role of experiential learning and parental involvement in sustainable health behavior change.

Data were analyzed using Jamovi. Descriptive statistics summarized baseline and post-intervention measures. Paired t-tests assessed changes in BMI, dietary intake, and nutrition-related behaviors. Non-parametric alternatives were applied when assumptions were not met.

Before participation, children and their parents or guardian received detailed information about the study, and written consent was obtained. Participation was voluntary, with the option to withdraw at any time.

No personally identifiable data were collected without consent. All data were anonymized and securely stored in compliance with the Data Privacy Act of 2012 (RA 10173). The study was approved by the Dr. Yanga's Colleges, Inc. Ethics Review Board. Subjects were debriefed before data collection, and the researcher's prioritized privacy, transparency, and integrity throughout the process.

3. RESULTS

The results of this study assessed improved weight status, knowledge on nutritional benefits of vegetables, perceptions of the role of vegetables on weight management and eating behaviors related to vegetable consumption. Additionally, it includes the results of t-test scores, showing the analysis and interpretation of significance between pre-test and post-test scores.

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Table 1. Pre- and Post-Intervention Changes in Nutritional Knowledge, Perceptions on Weight Management, and Vegetable Consumption Behaviors of Subjects

Parameters	Mean		SD		T Test	P Value	Cohen's d	Decisions
	Pre	Post	Pre	Post				
Weight Status (Weight, Height, Body Mass Index)								
Weight	23.4	25.1	5.96	6.13	-8.79	<0.001	-1.604	Reject
Height	130	14.8	14.8	15.0	-3.55	0.001	-0.648	Reject
Body Mass Index (BMI)	13.5	14.3	0.75	0.86	-9.64	<0.001	-1.759	Reject
Total	55.6	7.17	7.17	7.33	-21.9	0.001		
Knowledge on Nutritional Benefits of Vegetables								
1[1]	2.60	3.73	1.00	0.450	-5.959	<0.001	-1.088	Reject
2[2]	3.13	3.57	0.77	0.504	-2.538	0.017	-0.463	Reject
3[3]	3.63	3.77	0.71	0.430	-0.891	0.380	-0.163	Accept
Total	3.12	3.69	0.82	0.46	-3.129	0.132		
Perceptions of the Role of Vegetables on Weight Management								
13[4]	3.43	3.87	0.679	0.346	-3.07	0.005	-0.560	Reject
14[5]	3.53	3.90	0.730	0.254	-2.84	0.008	-0.519	Reject
15[6]	3.67	3.97	0.547	0.183	-2.76	0.010	-0.503	Reject
16[7]	3.43	3.83	0.626	0.379	-3.53	0.001	-0.644	Reject
17[8]	3.40	3.63	0.675	0.490	-1.65	0.109	-0.302	Accept
18[9]	3.53	3.90	0.629	0.305	-2.63	0.014	-0.479	Reject
Total	3.49	3.85	1.89	0.32	-2.74	0.024		
Eating Behaviors related to Vegetable Consumption								
4[10]	4.07	4.40	0.86	0.621	-1.90	0.067	-0.348	Accept
6[11]	2.13	1.67	0.97	0.802	-2.25	0.032	0.411	Reject
7[12]	2.37	4.23	1.03	0.774	-9.82	<0.001	-1.792	Reject
8[13]	4.17	4.57	0.91	0.626	-2.35	0.026	-0.429	Reject
9[14]	2.13	3.73	1.04	0.521	-8.45	<0.001	-1.543	Reject
10[15]	2.83	3.43	0.834	0.935	-2.90	0.007	-0.530	Reject
11[16]	3.20	3.73	0.925	0.450	-2.72	0.011	-0.496	Reject
Total	2.98	3.68	0.93	0.67	-4.34	0.020		

[1] I have seen or learned about aquaponics gardening.
[2] I know that Aquaponics combines fish farming and plant growing.
[3] I understand that different foods provide different nutrients that help my body grow.
[4] I include vegetables to help control my weight.
[5] I believe eating vegetables can help with weight management.
[6] I believe vegetables are key to a weight management diet.
[7] I am willing to eat vegetables grown in an Aquaponics Garden.
[8] I choose healthy foods for my meals and snacks.
[9] I include vegetables in my meals to help manage my weight.
[10] I eat vegetables with meals.
[11] I eat junk food instead of vegetables.
[12] I have tried vegetables grown in an Aquaponics system.
[13] I am interested in learning more about Aquaponics.
[14] I have eaten vegetables grown in an Aquaponics system.
[15] I have been eating more vegetables in my meals since I started eating aquaponics-grown vegetables.
[16] I have improved my health since eating aquaponics-grown food.

Weight Status (Weight, Height, Body Mass Index)

As shown in Table 1., subjects were classified as undernourished based on mean weight (M = 23.4 kg, SD = 5.96), height (M = 130.0 cm, SD = 14.8), and BMI (M = 13.5, SD = 0.75), with BMI scores ranging from 12.1 to 14.8 before intervention. This indicates that the children were underweight per the World Health Organization (WHO) BMI-for-age standards.

Following the intervention, mean weight increased to 25.1 kg (Mdiff = -1.73 kg), and BMI rose to 14.3 (Mdiff = -0.84), indicating positive shifts while still in the underweight range. Height improved to 131.3 cm (Mdiff = -1.34 cm). Paired t-tests confirmed statistically significant gains in weight, BMI, and height ($p < 0.001$). The large effect size for weight underscores the intervention's impact. Additionally, total scores across all parameters increased significantly from a pre-test mean of 55.6 to a post-test mean of 56.9 ($p = 0.001$).

Despite subjects remaining underweight, significant weight gain suggests early nutritional recovery, likely due to improved intake, absorption, and more consistent eating patterns encouraged by the gardening environment.

Knowledge on Nutritional Benefits of Vegetables

Table 1 also presents changes in children's understanding of aquaponics and nutrition. Before the intervention, subjects agreed they had seen or learned about aquaponics (M = 2.60, SD = 1.00) and understood its concept (M = 3.13, SD = 0.77). They strongly agreed that different foods provide nutrients for growth (M = 3.63, SD = 0.71). This shows that while children already had basic awareness of nutrition, their understanding of aquaponics specifically was still limited.

After the intervention, children strongly agreed they had seen or learned about aquaponics gardening (M = 3.73, SD = 0.45), knew that aquaponics combines fish farming and plant growing (M = 3.57, SD = 0.50), and understood that food provides nutrients for body growth (M = 3.77, SD = 0.43). The results show a shift from vague awareness to strong understanding of aquaponics and nutrition.

For Item 1, the mean increased from 2.60 to 3.73 (Mdiff = -0.7000, $t = -5.959$, $p < 0.001$), indicating significant improvement. For Item 2, the mean increased significantly from 3.13 to 3.57 (Mdiff = -0.4667, $t = -2.538$, $p = 0.017$), also significant. For Item 3, the increase from 3.63 to 3.77 (Mdiff = -0.2000, t

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= -0.891, p = 0.380) was not significant, likely due to prior knowledge.

Item 1 showed the most improvements, with a large effect size (Cohen's d = -1.088), suggesting that regular exposure during sessions enhanced learning about aquaponics gardening. The total score improved from 3.12 (SD = 0.82) to 3.69 (SD = 0.46), with t = -3.129 and p = 0.132. The intervention not only added new information but also expanded subjects' understanding of food systems. This is meaningful because understanding how food is grown helps promote a lifelong connection to healthy food and self-sufficiency.

Perceptions of the Role of Vegetables on Weight Management

Table 1 shows strengthened perception about vegetables' role in weight control. Pre-test scores already indicated strong agreement on key ideas: that vegetables help control weight (M = 3.43, SD = 0.68), aid in weight management (M = 3.53, SD = 0.73), are essential to a healthy diet (M = 3.67, SD = 0.55), and that subjects were willing to eat aquaponics-grown vegetables (M = 3.43, SD = 0.63). These initial beliefs reflect aspirational knowledge, children recognized the value of vegetables but may not have consistently practiced it. The general agreement may also be influenced by social desirability bias at school or home.

Following the intervention, all perception scores improved. Subjects more strongly agreed that vegetables help control weight (M = 3.87, SD = 0.35) and support weight management (M = 3.90, SD = 0.25). The belief that vegetables are key to weight-conscious diets also strengthened (M = 3.97, SD = 0.18). Willingness to eat aquaponics-grown vegetables increased to M = 3.83 (SD = 0.38), and more subjects included vegetables in meals for weight control (M = 3.90, SD = 0.31). These shifts suggest that the intervention not only reinforced existing beliefs that children became more open to eating vegetables they helped grow, indicating stronger engagement and trust in the produce.

Statistical analysis confirmed significant improvements in five of six items ($p < 0.05$). Item 13 (vegetables help control weight) increased by 0.44 (p = 0.005), indicating improved understanding. Items 14 and 15 (vegetables aid in weight control and are key to diet) also improved (p = 0.008, p = 0.010), reflecting stronger internalization of health concepts. Item 16 (willingness to eat aquaponics-grown vegetables) showed the largest change (p = 0.001; d = -0.644), highlighting the effect of hands-on exposure. Item 18 (including vegetables in meals) also increased ($p = 0.014$). Only Item 17 (choosing healthy food) did not improve significantly ($p = 0.109$), possibly due to limited household access.

The total mean increased from 3.49 (SD = 1.89) to 3.85 (SD = 0.32), with a significant t-value of -2.74 ($p = 0.024$). The intervention enhanced both knowledge and motivation, shifting children from general beliefs to experience-based understanding of vegetables in weight management.

Eating Behaviors related to Vegetable Consumption

Table 1 also captures behavioral changes in vegetable consumption. Initially, subjects reported frequently eating vegetables with meals (M = 4.07, SD = 0.86) and rarely choosing junk food instead (M = 2.13, SD = 0.97). However, few had tried aquaponics-grown vegetables (M = 2.37, SD = 1.03), though interest in aquaponics was already high (M = 4.17, SD = 0.91). Most had not consumed aquaponics produce (M = 2.13, SD = 1.04), but some believed they were eating more vegetables (M = 2.83, SD = 0.83) and that their health was improving (M = 3.20, SD = 0.93). These results are probably affected by the fact that the subjects have already started their vegetable intake prior to answering the survey questionnaire, which showed that there is a disconnect between belief and practice.

After the intervention, subjects reported always eating vegetables with meals (M = 4.40, SD = 0.62), choosing fresh over processed foods (M = 4.47, SD = 0.57), and rarely consuming junk food (M = 1.67, SD = 0.80; $p = 0.032$). An increase was seen in trying aquaponics-grown vegetables (M = 4.23, SD = 0.77; $p < 0.001$), eating them (M = 3.73, SD = 0.52; $p < 0.001$), and showing interest in aquaponics (M = 4.57, SD = 0.63; $p = 0.026$). Subjects also reported eating more vegetables (M = 3.43, SD = 0.94; $p = 0.007$) and improved health (M = 3.73, SD = 0.45; $p = 0.011$).

Statistically significant changes were recorded in nearly all items, except in vegetable intake with meals ($p = 0.067$), which showed slight but not significant improvement. The greatest behavioral shift occurred in trying aquaponics-grown vegetables (Item 7), with a large effect size (Cohen's d = -1.792), suggesting that repeated exposure led to acceptance and preference. The total score increased from M = 2.98 (SD = 0.93) to M = 3.68 (SD = 0.67; $p = 0.020$), confirming significant improvement in eating behaviors.

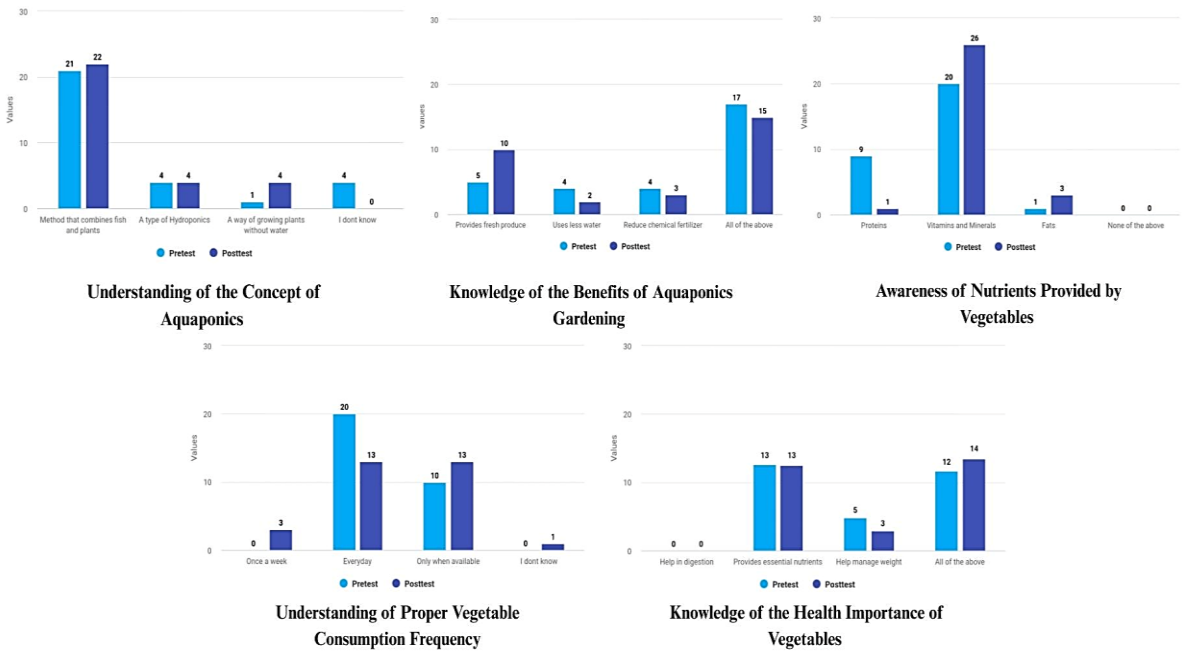

Figure 2. Subjects' Conceptual Grasp of Aquaponics Gardening: Knowledge, Interpretation, and Awareness

Understanding of the Concept of Aquaponics

Figure 2 illustrates the subjects' conceptual grasp of aquaponics gardening before and after the intervention. A total of 21 subjects (70%) correctly identified aquaponics gardening as a combination of growing plants and cultivating fish. Four (13%) associated it with hydroponics, describing it as a method using water and chemicals for plant growth. One (3%) compared it to traditional gardening with soil and fertilizer. The remaining four (13%) were unfamiliar and associated it only with traditional farming. Subjects may not fully understand aquaponics, especially the younger ones, but they grasped the idea that fish and plants benefit each other in the system.

Knowledge of the Benefits of Aquaponics Gardening

Figure 2 also shows how children's understanding of aquaponics benefits. Five (16%) identified it as a source of fresh food, four (13%) highlighted water-saving features, and another four (13%) noted reduced chemical use. Seventeen (56%) chose "all of the above," recognizing multiple benefits. In the post-test, some selected "fresh produce" after harvesting vegetables, while others chose water efficiency or reduced chemicals. Notably, "all of the above" responses dropped by 15 (50%), suggesting a shift from general to more specific understanding.

Awareness of Nutrients Provided by Vegetables

As shown in Figure 2, misconceptions about vegetable nutrients were common before the intervention. Nine (30%) believed vegetables provide protein, linking it to energy during play, a common misconception. Twenty (67%) correctly identified them as sources of vitamins and minerals, while one (3%) chose fat, indicating limited knowledge. In the post-test, most subjects answered correctly, though three (10%) still selected fat. When asked, they associated fats with meat consumed alongside vegetables. This suggests the intervention improved understanding but highlighted the need for continued reinforcement to address misconceptions.

Understanding of Proper Vegetable Consumption Frequency

Figure 2 also presents changes in how often children reported eating vegetables. In the pre-test, 20 (67%) reported eating vegetables daily, while ten (33%) ate them only when available, often influenced by family preferences. Post-test results differed from expectations. Only 13 (43%) reported daily consumption, another 13 (43%) ate vegetables only when available, typically during harvests, and 3 (10%) ate them once or twice a week to try aquaponics vegetables. One (3%) was unsure how often to eat vegetables.

These changes suggest that pre-test responses may have reflected perceived "correct" answers. After the intervention, subjects gave more honest responses, showing improved awareness. While knowledge has improved, access and household dynamics still limit daily consumption, which is important for follow-up program.

Knowledge of the Health Importance of Vegetables

Figure 2 concludes with insights into children's understanding of why vegetables matter for health. Thirteen (43%) said vegetables provide nutrients, five (17%) noted they help manage weight, and 12 (40%) recognized benefits for both weight and digestion. Since the pre-test followed initial gardening exposure, some understanding was already evident, though misconceptions about nutrients remained. Moreover, post-test results showed slight improvement, with two (6%) more subjects identifying multiple benefits. Most noted

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that vegetables help the body fight sickness. This suggests deeper understanding gained through continued exposure. Experiential learning helped correct misconceptions and expand awareness.

Figure 3. Dietary Frequency of Subjects from Week 1 to Week 6 of Intervention

Dietary Frequency of Subjects

Figure 3 shows the dietary frequency of vegetable-based dishes from Week 1 to Week 6. In the first week, 13 vegetable-based dishes were consumed based on the researcher's food guide. This increased to 31 dishes in Week 2, likely due to lessons on the health benefits of vegetables, particularly for weight management.

Intake dropped in Weeks 3 and 4 due to class suspensions caused by extreme heat, leading subjects to opt for more convenient processed foods. By Weeks 5 and 6, vegetable consumption increased again as classes resumed and subjects began forming healthier eating habits.

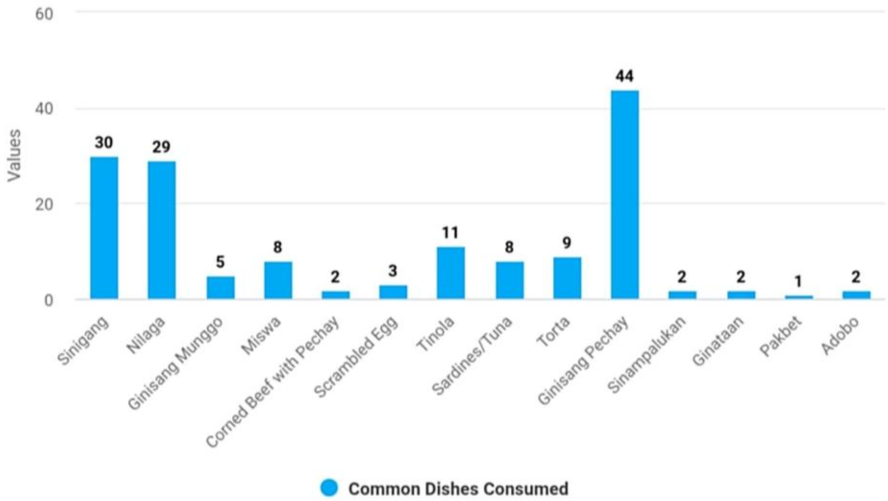

Figure 4. Common Dishes Consumed During the Aquaponics Gardening Interventions

Common Dishes Consumed During the Aquaponics Gardening Interventions

Despite the limited harvest of pechay and mustasa, subjects steadily increased vegetable consumption over the eight-week intervention (Figure 4). Commonly consumed dishes such as Ginisang Gulay (n = 44), Sinigang (n = 30), and Nilaga (n = 29) reflected the integration of available produce, supporting the findings in Table 4. Early weeks showed exploratory use of pechay, progressing to more frequent and confident inclusion in meals. Notably, dishes featuring other vegetables like okra, eggplant, and gabi began to appear, suggesting broader dietary influence beyond the intervention crops.

Low consumption of processed food (e.g., sardines, corned beef) further indicated a shift toward healthier eating. By Week 4, subjects demonstrated increased engagement in gardening tasks, highlighting ownership and enthusiasm. Recall data affirmed that even a basic aquaponics setup helped reduce barriers to vegetable inclusion, normalized their presence in daily meals, and encouraged active participation in food preparation. These outcomes underscore the potential of experiential learning in promoting sustainable improvements in children's dietary behavior

4. DISCUSSION

Given that the majority of assessed variables showed statistically significant changes, the null hypothesis was rejected. Results from pre- and post-test comparisons showed improvements in weight, knowledge, perception, and behavior toward vegetable consumption. Brief gardening exposure increased children's interest in vegetables and improved weight-related outcomes.

The changes in observed weight and BMI (mean BMI changes from 13.5 to 14.3) are consistent with findings from the MALAMA Project in Hawaii, which showed community aquaponics systems were associated with an increase in vegetable consumption and more positively BMI, particularly children (Chung-Do et al., 2024). Similarly, this study demonstrated that aquaponics gardens serve as a sustainable food source that supports healthier weight. Even slight improvements in weight and height are known to boost immunity and cognitive development, making them indicators for sustaining nutrition interventions (Roberts, 2022).

The hands-on gardening experience also enhanced children's knowledge of aquaponics. Initially unfamiliar, subjects later demonstrated improved understanding of its benefits, such as fresh, chemical-free food and efficient water use. This supports Kluczkovski et al. (2024), who found school-based aquaponics boosted food literacy and vegetable interest through experiential learning.

Children's beliefs about the role of vegetables in weight management improved, showing the intervention influenced behavior. While pre-test responses reflected general ideas that vegetables are healthy, post-test answers showed stronger motivation to consume aquaponics-grown produce. However, some misconceptions remained, such as thinking vegetables provide fats, highlighting the need for sustained interventions to reinforce correct nutritional understanding (Maneschy et al., 2024).

The study found that while perceptions and behavior toward vegetables improved and consumption increased, daily intake remained limited. This suggests that factors like household food practices and access may have moderated behavior change, which is consistent with Kluczkovski et al. (2024), who emphasized the role of home environment. Notably, children who harvested vegetables twice a week also tended to consume them twice weekly, indicating a clear link between access and eating habits.

Week-to-week changes in vegetable intake highlighted how environmental and logistical challenges, like class suspensions due to extreme heat, impacted consumption. As noted by Rojas et al. (2024), such disruptions can affect food supply chains. During these weeks, some children reverted to processed foods, but intake improved by Weeks 5 and 6, suggesting the formation of adaptive eating habits. While similar to home gardening (Mok et al., 2022; Santos et al., 2022), aquaponics is more resource-efficient, requiring less space and water, producing both fish and vegetables, and fitting well in urban, resource-limited settings. This supports findings by Okomoda et al. (2022) and Shumet (2021), on aquaponics' ecological and nutritional benefits.

While the intervention was successful, limitations remain. Despite BMI improvement, most children were still underweight post-intervention. Thus, while aquaponics aids recovery, it cannot stand alone. It requires additional long-term support like nutrient supplementation or protein-rich foods (Amadou & Lawali, 2022).

To apply the findings of this study into nursing practice, it is recommended that community health nurses receive training in aquaponics facilitation to support sustainable nutrition programs in undernourished communities. Implementing aquaponics-based interventions in barangays with high rates of childhood undernutrition may also strengthen nurse–community relationships by fostering active participation and experiential learning. Nurses are further encouraged to advocate for eco-friendly nutrition initiatives aligned with national programs such as the "Gulayan sa Paaralan", reinforcing their role in community empowerment and health promotion. Additional interventions may include organizing school-based gardening workshops led by nurses and local health workers, developing nutrition education materials tailored for children and parents, and collaborating with barangay officials to integrate aquaponics into local health and feeding programs. These efforts can help normalize vegetable consumption, improve food literacy, and promote long-term behavioral change in nutritionally vulnerable populations.

The findings support Bandura's Social Cognitive Theory (SCT), which highlights the interplay of personal, behavioral, and environmental factors in learning (Rumjaun & Narod, 2020). The intervention enhanced children's nutrition knowledge encouraged healthier food choices through hands-on engagement and created a supportive environment through access and peer influence. Together, these changes reflect reciprocal determinism, showing how meaningful shifts in one area can reinforce positive outcomes in others, demonstrating SCT's value in shaping lasting, health-promoting habits.

Although the study aimed to address underweight conditions among children, several limitations were noted. The main constraint was financial. While basic components like pipes and electricity were covered, the vegetable yield was only sufficient for the exact number of subjects. Due to this, the sample size was limited to 30, which may affect the reliability of generalizations. Delays in vegetable production also occurred, limiting supply to just two days' worth. Peak summer heat also prompted parents to request afternoon sessions, reducing subjects' gardening exposure. Additionally, locating a licensed nutritionist to validate the survey took over a week, shortening the time available for data gathering and gardening activities. Lastly, the instrument was not formally validated within a Filipino population. This limitation may affect the generalizability and interpretability of the findings.

For future research, aquaponics gardening shows strong potential in improving nutrition literacy and food security. It is recommended for integration into the Community Health Nursing curriculum to equip students with practical skills to address undernutrition. In practice, it may be implemented in high-risk areas. Future studies may explore longer interventions, larger samples, organic yield improvement, and better space use. Sustaining the program will require funding, scheduling support, and community engagement.

5. CONCLUSION

In conclusion, this study showed aquaponics gardening has both feasible and meaningful potential for improving undernourished children's health and overall well-being. The intervention represented a multi-dimensional educational tool that not only produced food but improved vegetable intake, weight status, nutrition knowledge, and positive beliefs in healthy eating.

As an intervention grounded in Bandura's Social Cognitive Theory the program provided behavioral change through observation, positive reinforcement and self-efficacy. Statistically significant improvements in weight, BMI and health behaviors reflect meaningful change towards improved nutritional status, although these children remained in the underweight category. The findings support aquaponics gardening for childhood undernutrition addressing long-term solutions in sustainable, community-based models especially in lower income communities when access to funds is limited by constraining food systems.

Overall, this study demonstrates that a brief, hands-on gardening experiential program that exposes children to changing health habits and initiates a step towards sustainable long-term dietary shift and resilience. To maximize its effectiveness, further research should explore the scalability of aquaponics gardening in various community settings, the long-term sustainability of its nutritional impacts, integration into school curricula and public health programs, as well as its cost-efficiency compared to traditional feeding interventions. Moreover, studies should investigate how family involvement, cultural food preferences, and environmental factors influence the success of aquaponics-based interventions in diverse socio-economic contexts.

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AUTHOR CONTRIBUTIONS

Substantial contributions to conception, data collection, analysis, writing, and manuscript revisions: Mikylla Lorraine F. Cruz, Regie P. De Jesus, Airone A. Arcojo, Jack Ivan A. Hernandez, Peterson J. Yanson, Luther S. Siosana.

CONFLICT OF INTEREST

There are no potential conflicts of interest to declare.

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DATA AVAILABILITY

The data obtained in this study have not been disclosed to the public for privacy protection and ethical reasons.

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