



Enhancing Food Security and Nutrition in Early Childhood: Development and Effect of the Central Kitchen Model in Thai Child Development Centers

Pattaraporn Charoenbut¹, Duangdao Sudatip¹

¹ Faculty of Public Health, Ubon Ratchathani Rajabhat University

Corresponding author: Pattaraporn Charoenbut; Email: pattaraporn.c@ubru.ac.th

Received: November 16, 2024 **Revised:** July 20, 2025 **Accepted:** December 10, 2025

Abstract

Nutrition plays a vital role in early childhood development. However, rural child development centers struggle with inconsistent meal quality due to fragmented food service systems and limited nutritional expertise in developing standardized meal menus. This study aimed to develop and evaluate the Central Kitchen Model (CKM) to enhance the nutritional quality of meals in child development centers (CDCs). Using a Participatory Action Research (PAR) approach, the study employed a three-phase approach: (1) baseline assessment of current practices and nutritional status, (2) collaborative model development through stakeholder workshops that engaged 35 participants, including teachers, cooks, and parents, across nine CDCs in Ubon Ratchathani Province, and (3) implementation and evaluation over a 12-week period. The implementation involved standardizing meal preparation protocols, conducting nutrition education workshops for staff and parents, and promoting locally sourced ingredient integration. Nutritional outcomes were evaluated using the INMUCAL Program Version 3.0, anthropometric measurements, and behavioral assessments. Post-intervention analysis revealed significant improvements in meal nutritional value, with average energy content increasing from 349.42 to 414.34 kcal and protein levels rising from 14.00 to 16.96 g. Children's vegetable recognition scores improved from 1.70 to 2.65, and their ability to identify vegetable-based dishes increased from 1.80 to 3.55. Children's height measurements showed significant improvement, indicating positive growth outcomes. The model fostered community engagement through participatory menu planning and local ingredient sourcing, demonstrating CKM's potential to address childhood malnutrition through sustainable food security and nutrition practices. This framework offers a scalable approach for enhancing child health outcomes and empowering communities to achieve long-term nutritional stability.

Keywords: central kitchen model; child development centers; food security; participatory action research

การส่งเสริมความมั่นคงทางอาหารและโภชนาการในเด็กปฐมวัย: การพัฒนาและผลของรูปแบบครัวกลางในศูนย์พัฒนาเด็กเล็กของไทย

Enhancing Food Security and Nutrition in Early Childhood:

Development and Effect of the Central Kitchen Model in Thai Child Development Centers

ภัทรพร เจริญบุตร¹, ดวงดาว สุดาทิพย์¹

Pattaraporn Charoenbut¹, Duangdao Sudatip¹

¹ คณะสาธารณสุขศาสตร์ มหาวิทยาลัยราชภัฏอุบลราชธานี

¹ Faculty of Public Health, Ubon Ratchathani Rajabhat University

Corresponding author: Pattaraporn Charoenbut; Email: pattaraporn.c@ubru.ac.th

Received: November 16, 2024 Revised: July 20, 2025 Accepted: December 10, 2025

บทคัดย่อ

โภชนาการมีบทบาทสำคัญต่อการพัฒนาเด็กปฐมวัย อย่างไรก็ตามศูนย์พัฒนาเด็กในพื้นที่ชนบทประสบปัญหาคุณภาพอาหาร เนื่องจากระบบบริการอาหารที่ไม่เป็นระบบและข้อจำกัดเรื่องความเชี่ยวชาญด้านโภชนาการในการทำเมนูอาหารตามมาตรฐาน งานวิจัยนี้มีวัตถุประสงค์เพื่อพัฒนาและประเมินผลรูปแบบ “ครัวกลาง” (Central Kitchen Model: CKM) ในการยกระดับคุณภาพมื้ออาหารในศูนย์พัฒนาเด็กเล็ก โดยใช้กระบวนการวิจัยเชิงปฏิบัติการแบบมีส่วนร่วม (Participatory Action Research: PAR) ใน 3 ระยะ ได้แก่ (1) การประเมินสถานการณ์พื้นฐานของแนวปฏิบัติด้านอาหารและภาวะโภชนาการ (2) การพัฒนารูปแบบร่วมกับผู้มีส่วนเกี่ยวข้องจำนวน 35 คน ประกอบด้วยครู ผู้ประกอบอาหาร และผู้ปกครองเด็กจาก 9 ศูนย์พัฒนาเด็กเล็กในจังหวัดอุบลราชธานี และ (3) การดำเนินการและประเมินผลในระยะเวลา 12 สัปดาห์ การดำเนินงานประกอบด้วย การจัดทำมาตรฐานการประกอบอาหาร การจัดอบรมเชิงปฏิบัติการเพื่อให้โภชนศึกษาแก่ครูและผู้ปกครอง และการส่งเสริมการใช้วัตถุดิบในท้องถิ่น การประเมินผลลัพธ์ด้านโภชนาการประกอบด้วยการวิเคราะห์คุณค่าทางโภชนาการโดยโปรแกรม INMUCAL เวอร์ชัน 3.0 การวัดสัดส่วนร่างกาย และการประเมินพฤติกรรม ผลการวิเคราะห์หลังการดำเนินการพบการปรับปรุงอย่างมีนัยสำคัญด้านคุณค่าทางโภชนาการของมื้ออาหารดีขึ้น โดยพลังงานเฉลี่ยเพิ่มขึ้นจาก 349.42 เป็น 414.34 กิโลแคลอรี และโปรตีนเพิ่มจาก 14.00 เป็น 16.96 กรัม คาร์โบไฮเดรตของเด็กรวมจาก 1.70 เพิ่มขึ้นเป็น 2.65 และความสามารถระบุเมนูที่ทำจากผักได้ดีขึ้นอย่างมีนัยสำคัญจาก 1.80 เพิ่มขึ้นเป็น 3.55 ในขณะเดียวกันส่วนสูงของเด็กก็เพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ นอกจากนี้ รูปแบบครัวกลางยังส่งเสริมการมีส่วนร่วมของชุมชนผ่านกระบวนการวางแผนเมนูแบบมีส่วนร่วมและการใช้วัตถุดิบจากท้องถิ่น ซึ่งแสดงให้เห็นถึงศักยภาพของรูปแบบครัวกลางในการแก้ปัญหาภาวะทุพโภชนาการในเด็ก ด้วยแนวทางที่ยั่งยืนด้านความมั่นคงทางอาหารและโภชนาการ กรอบแนวคิดนี้สามารถขยายผลไปยังพื้นที่อื่นๆ ได้เพื่อยกระดับสุขภาวะเด็กและเสริมสร้างพลังให้ชุมชนด้านโภชนาการที่ดีในระยะยาว

คำสำคัญ: การวิจัยเชิงปฏิบัติการแบบมีส่วนร่วม; ความมั่นคงทางอาหาร; รูปแบบครัวกลาง; ศูนย์พัฒนาเด็กเล็ก



INTRODUCTION

Early childhood is a critical stage for physical and cognitive development, and adequate nutrition plays a vital role in shaping long-term health outcomes.¹ In Thailand, however, the dual burden of malnutrition—manifested as both undernutrition and increasing childhood obesity—remains a persistent public health challenge.² According to national statistics³, 10.5% of children under five are stunted, reflecting chronic undernutrition, while poor dietary habits and high consumption of processed foods contribute to rising obesity rates. This nutritional crisis is no longer confined to affluent urban areas but increasingly affects rural populations,⁴ highlighting the urgent need for systematic intervention approaches.

Ubon Ratchathani Province, located in northeastern Thailand with over 1.8 million residents, exemplifies Thailand's complex nutrition challenges. Provincial health data from 2022 reveals that 6.3% of preschool children are underweight, 9.5% are stunted, and 10.58% are overweight or obese.⁵ Within the province, Khueang Nai District faces particularly high prevalence of child stunting (17%) and obesity (11.2%).⁶ Many of these rural children rely on child development centers (CDCs) for daily nutrition support, making meal quality in these facilities critical for addressing malnutrition.

Child development centers are ideal environments for fostering healthy habits in young children and therefore play a crucial role in addressing nutritional challenges, as interventions delivered in early childhood education and care settings have been shown to improve diet quality and reduce the risk of overweight and obesity.⁷⁻⁸ However, preliminary analysis by the research team revealed that despite existing guidelines and standards for lunch service provision in child development centers, implementation remains inconsistent and often fails to meet nutritional requirements in rural settings.⁹ This implementation gap is particularly evident in Ko Ae sub-district (Khueang Nai district), where despite having nine child development centers under coordinated sub-district administration organization oversight, actual compliance and quality monitoring remain inadequate, reflecting broader systemic challenges that require innovative intervention approaches.

Previous intervention efforts in Ubon Ratchathani have demonstrated both the potential and limitations of traditional approaches to improving child nutrition services. A comprehensive community-based study in Patum sub-district revealed that preschool children faced nutritional problems, including weight exceeding standards (10.45%), below standard weight (4.54%), and combined weight and height deficiencies (15%).¹⁰ This study, involving 70 stakeholders from local government organizations, healthcare professionals, teachers, and community representatives, identified critical gaps in nutrition management including limited support from both official and unofficial entities, minimal information and budget coordination between organizations, and low personnel competency in children's nutrition. Another intervention in Rai Noi sub-district targeting teachers and caregivers improved meal planning awareness but failed to establish standardized food service protocols or structural reforms within meal



delivery systems.¹¹ These findings, combined with the persistent implementation gaps observed across Khueang Nai district's child development centers, underscore the need for more comprehensive, participatory systems-based solutions developed through co-design processes with community stakeholders to ensure local ownership and sustainability.

To address these systemic challenges, this study developed and implemented a comprehensive central kitchen model using participatory action research methodology. The research was conducted in Khueang Nai District's nine child development centers, leveraging their clustered administrative structure to systematically test the Central Kitchen Model (CKM) framework's effectiveness in addressing identified gaps in rural child nutrition services.

OBJECTIVES

This research aimed to develop and evaluate the effectiveness of the Central Kitchen Model for enhancing nutritional quality of meals in Thai child development centers using a participatory action research approach, with specific focus on:

1. To assess the current state of food security and nutritional practices in participating child development centers.
2. To develop a culturally appropriate Central Kitchen Model through stakeholder engagement.
3. To evaluate the effectiveness of the Central Kitchen Model by measuring nutritional quality of served meals and the satisfaction of the participants.

MATERIAL AND METHODS

Research Design

Guided by the principles of Participatory Action Research (PAR)¹²⁻¹³, this study engaged stakeholders throughout the process to co-develop the CKM that responds to local needs in early childhood nutrition and food management. The PAR process followed a Plan-Act-Observe-Reflect (PAOR) cycle, allowing for iterative learning, joint problem-solving, and capacity building across all levels. Prior to selecting the CKM as an intervention strategy, the research team conducted a series of participatory problem-identification meetings with key stakeholders—including teachers, cooks, parents, and local administrative officers. These discussions surfaced several critical challenges: meals often failed to meet nutritional standards; many children resisted eating vegetables; teachers faced difficulties encouraging children to consume balanced meals; and local administrative organizations lacked effective mechanisms to monitor food service quality across centers.



PAR Cycle Implementation

Phase 1: Participatory Situation Analysis

An assessment of current food service practices, food security, and nutritional challenges in child development centers (CDCs) was conducted. Participants included 17 cooks, 35 teachers, and 6 policy-level stakeholders. Issues identified included lack of standardized menus, limited vegetable inclusion, and absence of systematic oversight.

Phase 2: Co-Design and Action Implementation

A multidisciplinary group—comprising 9 cooks, 18 teachers, parents, and 9 local policymakers—collaboratively developed the CKM. Participatory workshops focused on nutrition education, hygiene, and menu planning. A one-month rotating lunch menu was co-designed, consisting of 22 protein-based dishes, 8 culturally acceptable snacks, and 8 seasonal fruits. National preschool nutrition standards were embedded via annotated menu notes to guide implementation. Real-time feedback in week 6 led to adjustments in meal sequence and portion size.

Development of the CKM was guided by the Ministry of Public Health's 2015 school lunch framework⁷ and the FAO School Food and Nutrition Framework¹⁴. These were used as flexible guiding tools rather than rigid templates. Adaptations included vegetable gardening, menu planning with local ingredients, and participatory monitoring. The Education and Culture Division of the Ko-Ae Subdistrict Administrative Organization later endorsed the model, requiring all CDCs to report lunch practices via LINE group communication for ongoing quality assurance. **Figure 1** illustrates the CKM's three integrated pillars: food security through local sourcing and gardening, standardized meal planning, and nutrition monitoring.

Phase 3: Reflection and Evaluation

In week 12, assessments were conducted to evaluate changes in children's nutritional status, vegetable knowledge, and stakeholder practices. Teachers and public health nurses measured children's height and weight and monitored developmental milestones. Reflection meetings guided further improvement. Parent workshops emphasized balanced diets at home, supporting continuity of healthy eating beyond the CDC setting.

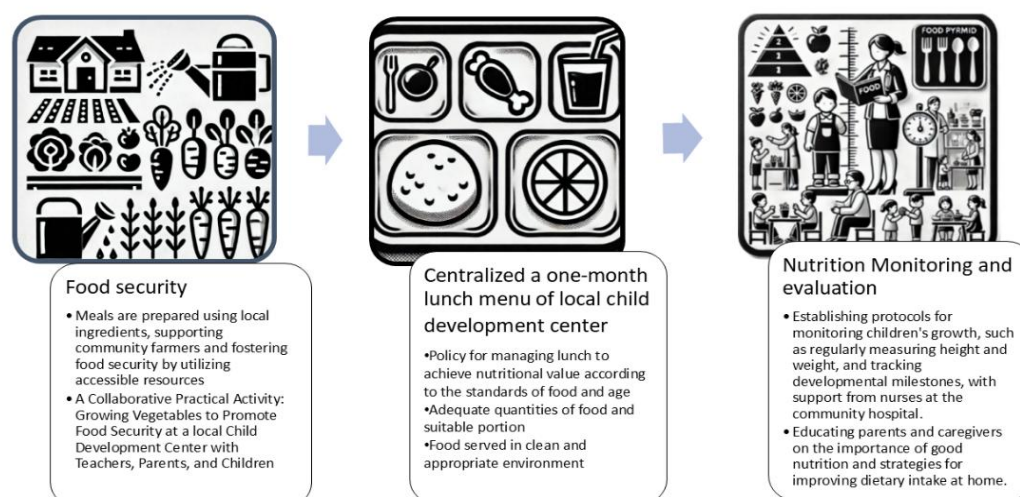


Figure 1 The Central Kitchen Model in Child Development Centers

Study Setting and Participants

The study was conducted in nine child development centers located in Khueang Nai District, Ubon Ratchathani Province, under the administration of the Ko-Ae Sub-district Administrative Organization. Participants included 17 cooks, 35 childcare teachers, and 9 policy-level stakeholders such as local government officials and CDC committee members. Additionally, two university faculty members with expertise in nutrition and early childhood education were involved as research collaborators. Additionally, 20 preschool children were included in the outcome evaluation to assess changes in anthropometric status and vegetable consumption behavior. Twenty parents who participated in gardening and nutrition promotion activities were also involved during Phase 3 to provide insights into dietary continuity at home.

Data Collection Tools and Procedures

A mixed-methods approach was employed. Quantitative data included pre- and post-intervention questionnaires for teachers, cooks, and parents, anthropometric measurements (height and weight) of preschool children, and dietary assessments using a 3-day food weighing method and direct observation of lunch servings. Children's knowledge of vegetables was evaluated using a structured vegetable recognition assessment tool, which captured their ability to name vegetables and identify vegetable-based dishes. Qualitative data were collected through in-depth interviews and focus group discussions with stakeholders to capture experiential insights and reflections throughout the PAR process.

Quality Control of Research Tools

Tools were reviewed by five experts in nutrition, preschool education, and public health to ensure alignment with research objectives. The item-objective congruence (IOC) index was used, and only items with IOC values of 0.75 or higher were selected. Standard nutrition assessment forms were reviewed and validated by nutrition experts. Instruments were pre-tested with a similar population in a



nearby CDC to refine clarity, language, and item sequencing. Cronbach's alpha for internal consistency was .81.

Data Analysis

Descriptive statistics (frequency, percentage, mean, and standard deviation) were used to summarize baseline and post-intervention data. Paired t-tests were employed to compare pre- and post-intervention outcomes related to nutritional status and vegetable knowledge assessment. Nutritional values of the standardized menus were analyzed using the INMUCAL Program Version 3.0 to ensure adherence to national dietary standards.

Ethical Considerations

This study received ethical approval from the Human Research Ethics Committee at Ubon Ratchathani Rajabhat University (Approval No. HE62019), dated June 26, 2019. Participants were informed of their rights and provided written consent prior to participation.

RESULTS

The research findings were as follows.

1. The characteristics and lunch service operations of preschool child development centers

The number of personnel in the CDC was mostly less than 3 persons (66.6%), and there was likely one person involved in food services (50.0%). The educational background of the personnel was noteworthy, with the majority holding undergraduate degrees or higher (65.2%). Additionally, the results of food security situation in child development centers, as well as the efficiency of their nutrition and lunch service operations. These findings, summarized in **Table 1**.

Table 1 Information of personnel involved in catering in child development centers (CDC)

Personnel information related to food catering	amount	percent
Number of personnel in the CDC		
1-3 persons	8	66.6
4-6 people	2	16.7
7 or more	2	16.7
total	12	100.0
Number of personnel involved in catering	number	percent
1 person	6	50.0
2 persons	2	16.7
3 persons	4	33.3
Total	12	100.0
Education level of personnel involved in catering		
Uneducated	0	0.0
Elementary School	5	21.8



Personnel information related to food catering	amount	percent
Secondary School	2	8.7
Diploma	1	4.3
Undergraduate degree or higher	15	65.2
Total	23	100.0

Moreover, findings from interviews with teachers, cooks, and parents revealed that communities supporting the child development centers engage in year-round crop cultivation for local consumption, reflecting a self-sufficient approach to food access. There were no reported issues with accessing local food within these communities. The primary source of raw materials for the centers is purchases from local markets, followed by direct purchases from farmers, ensuring fresh and locally sourced ingredients. Milk, a staple for children, is primarily purchased from dairy companies. Food menus are typically determined collaboratively by the head of the CDCs and the cook, ensuring alignment with nutritional standards and available resources. The majority of cooks (66.7 %) are hired to prepare meals, with the culinary operations of the centers. This system reflects an efficient and community-integrated approach to meal preparation, leveraging local resources and opportunity to support children's nutrition.

2. Results of CKM implementation

The implementation of the Central Kitchen Model (CKM) yielded significant improvements across several key areas:

1. Nutritional Value of Meals

The nutritional quality of meals provided to preschool children improved markedly. Post-intervention analysis revealed increased energy and protein content in lunches, as shown in Table 2 and Table 3, with meals meeting recommended dietary standards for preschool-aged children. For example, the average energy content increased from 349.42 kcal to 414.34 Kcal, while protein levels rose from 14.00 g to 16.96 g.

2. Community Involvement and Economic Impacts

The model fostered greater community engagement by involving parents, teachers, and local farmers in various activities. The sourcing of fresh ingredients from local farmers not only ensured high-quality produce but also stimulated the local economy. Additionally, parents and teachers participated in nutrition promotion and food preparation, creating a sense of ownership and collaboration. This community-centered approach strengthened local food systems, promoted sustainable practices, and empowered stakeholders to maintain the program's benefits long-term.

These results highlight the effectiveness of the Central Kitchen Model in addressing nutritional challenges while fostering sustainable community development and dietary improvements.

**Table 2** Comparison of average nutrient composition and energy proportions of lunch before and after the intervention.

Nutrient	Mean \pm SD	
	Before	After
Energy (calories)	349.42 \pm 60.43	414.34 \pm 197.89
Carbohydrates(g)	55.21 \pm 3.07	61.76 \pm 39.93
Fat (g)	7.94 \pm 5.80	10.92 \pm 3.71
Protein (g)	14.00 \pm 5.88	16.96 \pm 6.84

Table 3 Comparison of average nutrient and total energy proportions of lunch served before and after the intervention.

Nutrient	Mean \pm SD	
	Before	After
Carbohydrate percentage	64.99 \pm 14.27	55.43 \pm 13.73
Protein percentage	15.73 \pm 5.34	18.27 \pm 7.23
Fat percentage	19.28 \pm 11.04	26.29 \pm 9.68
Energy Percentage	26.88 \pm 4.65	31.87 \pm 15.22

Nutritional status of preschool children

Results of nutritional status of preschool children using the weight for age, height for age and weight for height indicators found that there were different. However, measurement of body weight and height before and after implementation of the CKM found significantly significant as shown in **Table4**.

Table 4 The comparison of average weight and height of preschool children before and after (n=16)

Body weight and height of preschool children		Mean	SD	t	p-value
Body weight (Kg)					
	Before	17.03	2.70	1.962-	069.
	After	17.14	2.75		
Height (cm)					
	Before	105.69	6.38	-2.666	.018
	After	106.44	7.11		

The researcher promoted vegetable consumption in early childhood through a workshop to empower teachers who take care of children by providing knowledge on how to make media to promote vegetable consumption. Preschool children's knowledge on vegetable consumption before and after implementation of the CKM found significantly significant as shown in **Table5**. In addition, the researcher organized workshops for parents and children in the center through organizing learning experiences about vegetables, such



as making vegetable models, telling stories, planting vegetables, and testing the results of organizing activities to promote vegetable consumption in early childhood children. The results of the study were as follows: The score of naming vegetables increased. Before the experiment, the average score was 1.70. After the activity, the score increased to 2.65. Children were able to name food made from vegetables significantly more, with an average score of 1.80 before the activity and an average score of 3.55 after the activity.

Table 5 Preschool children's knowledge on vegetable consumption (n=20)

activity		Mean	SD	t	p-value
Name of vegetables					
	before	1.70	.80	-3.442	.003
	after	2.65	1.23		
Name the food that is made from vegetables					
	before	1.80	1.51	-4.027	.001
	after	3.55	1.43		

Results of CKM evaluation:

After the completion of interventions, in-depth interviewed with teachers, childcare workers, and cooks, which focused on exchanging knowledge, learning, and reflecting on lessons from the research, significant insights were gained. Following the implementation of the research activities, participants provided feedback on the use of the standardized central kitchen menu. These findings highlighted practical aspects of the menu's effectiveness, feasibility, and adaptability, offering valuable input for refining and sustaining nutrition-focused initiatives in child development centers.

Post-intervention feedback from teachers and cooks highlighted the perceived benefits, feasibility, and acceptability of the CKM in practice. Stakeholders consistently emphasized that standardized menus contributed to more consistent nutritional delivery, reduced subjectivity in food selection, and enhanced children's acceptance of meals. Several teachers noted that the menu allowed children to receive complete nutrients and promoted dietary variety, with many children enjoying the meals provided.

Cooks reflected positively on the model's standardization, explaining that previous menu planning often depended on individual preferences of staff, which led to inconsistencies in meal quality. By contrast, the CKM provided a structured guideline that was perceived as fair, practical, and nutritionally sound. Teachers also remarked on the successful continuation of the model even after the formal project concluded, with the LOA administrative encouraging its wider adoption across centers. Additional



practices such as decorating seasonal fruits, encouraging children to use their own cutlery, and daily photo sharing in communication groups were seen as reinforcing hygiene and engagement.

DISCUSSION

This study aimed to develop and evaluate a Central Kitchen Model (CKM) that integrates food security, nutrition education, and community participation to improve the quality of meals and nutritional outcomes for preschool children in rural Thailand. The findings confirm that the CKM intervention—developed through Participatory Action Research (PAR)—successfully addressed key challenges identified in the baseline phase, including inadequate energy and protein intake, low vegetable consumption, and the absence of standardized meal services across child development centers (CDCs). Additionally, there was significant improvement in meal nutritional quality—demonstrated by increases in energy content and protein levels—aligning with international evidence on structured school feeding programs. These nutritional enhancements occurred through several mechanisms identified in our PAR process: standardized menu planning ensured consistent nutrient delivery, while participatory vegetable gardening activities increased both vegetable availability and children’s willingness to consume them. This supports Drake et al.’s findings that structured meal programs providing at least one-third of daily nutritional requirements improve both immediate consumption patterns and long-term dietary behaviors.¹⁵ Similarly, Van et al.’s study on community-led Central Kitchen Models demonstrated that such approaches succeed by combining technical meal standards with local food system integration, creating sustainable improvements in both food quality and accessibility.¹⁶ Their research showed that when communities actively participated in model development—as in our study—implementation barriers decreased while cultural appropriateness and stakeholder commitment increased, leading to sustained nutritional improvements.

Our findings extend a food and nutrition management program at Rai Noi Subdistrict Child Development Center improved awareness and practices among teachers, parents, and food preparers¹¹. While their intervention focused primarily on nutrition education and showed promising changes in knowledge and attitudes, our study demonstrates how a more comprehensive approach through the CKM produces measurable improvements in meal nutritional content and children’s outcomes. Pinthong’s research identified the potential for local interventions but was limited to a single center and did not address the systemic challenges in standardizing meal preparation across multiple centers or integrating local food systems with meal planning. Our PAR approach expanded on their foundation by engaging stakeholders in developing structural solutions to these challenges across nine centers, resulting in concrete improvements in meal energy content and protein levels. Additionally, our model’s emphasis on sustainable implementation through local ownership addresses a limitation identified in Pinthong’s work, where maintaining changes after the intervention period remained a challenge. This comparison highlights how PAR methodologies can build upon knowledge-focused interventions to create sustainable systems



change in early childhood nutrition through community ownership and structural modifications to food service operations.

The development of our CKM through stakeholder engagement, our second research objective, demonstrated how PAR methodologies create contextually appropriate interventions. Unlike conventional nutrition programs that often impose standardized approaches, our collaborative process engaged teachers, cooks, parents, and administrators in identifying locally feasible solutions. This resulted in a model that balanced nutritional science with practical implementation considerations, such as adapting portion sizes based on age-specific consumption patterns observed by teachers and integrating seasonal vegetables available in the local agricultural system. The Food and Agriculture Organization's School Food and Nutrition Framework¹⁶ emphasizes this integration of local food systems into school nutrition programs as essential for both nutritional adequacy and program sustainability. Our findings extend this framework by documenting specific processes through which stakeholder participation shapes model development, from initial problem identification through implementation adaptations.

The improvements in children's anthropometric measurements and vegetable knowledge demonstrate how structural changes in meal provision can influence both physical development and food literacy. The significant height increase suggests that even a relatively short intervention period can impact growth trajectories when nutritional quality improves substantially. Similarly, the enhanced vegetable recognition and identification skills among children reflect how the model's integration of food education with improved meal content created mutually reinforcing pathways to better nutrition. This bidirectional relationship between food environments and nutrition knowledge aligns with the WHO School Policy Framework¹⁷, which emphasizes comprehensive approaches that address both food access and nutrition literacy.

The sustainability of these improvements, as evidenced by continued implementation after the formal research period, demonstrates the value of our participatory approach in creating lasting change. This sustainability resulted from several factors identified in our evaluation: administrative support from local authorities, practical feasibility within existing resource constraints, and the development of simplified tools that CDC staff could readily implement in daily operations. Moreover, the inclusion of continuous monitoring and evaluation mechanisms—such as routine growth monitoring, daily meal documentation, and participatory reflection meetings—proved essential to the CKM's sustained effectiveness. These feedback systems allowed stakeholders to identify implementation challenges early and make evidence-based adaptations, as demonstrated in the week 6 adjustments to portion sizes and vegetable preparation methods. The iterative evaluation approach inherent to PAR created a dynamic model that remained responsive to children's evolving dietary needs and contextual changes in food availability.

In conclusion, this study demonstrates that the Central Kitchen Model developed through our PAR process effectively enhanced nutritional quality, improved children's growth and vegetable



knowledge, and established sustainable food service practices in participating CDCs. The findings highlight the value of integrating structured nutritional guidelines with participatory development processes, creating interventions that are both technically sound and contextually appropriate. This approach offers a promising framework for addressing childhood nutrition challenges in similar settings, particularly when adapted through authentic stakeholder engagement.

LIMITATIONS

This study had several limitations. First, the intervention was conducted in a limited number of child development centers (CDCs) within a single district, which may limit the generalizability of the findings to other regions. Second, the intervention period of 12 weeks may not fully capture long-term outcomes, especially regarding changes in body weight and sustained behavior. Third, while the participatory action research (PAR) process provided deep contextual understanding and stakeholder ownership, it also required intensive coordination, which may challenge scalability in other settings. Lastly, although objective methods such as food weighing and leftover observation were employed to estimate vegetable consumption, these were not conducted across all centers and may be influenced by daily variability in food preparation and children's preferences.

RECOMMENDATIONS

1. A centralized menu planning and quality control system should be implemented across all child development centers to ensure consistent nutritional value in meals.
2. Capacity-building workshops should be regularly held for teachers, cooks, and parents to improve knowledge and awareness of child nutrition.
3. The use of locally sourced ingredients from community farmers should be encouraged to support local economies and promote a sustainable food system.
4. Future studies should investigate the long-term effects of the Central Kitchen Model on nutritional status and developmental outcomes in early childhood using longitudinal designs.

Acknowledgement

This research was granted by Ubon Ratchathani Rajabhat University. We also thank the staff and participants of the studied child day care centers.



References

1. Rosales FJ, Reznick JS, Zeisel SH. Understanding the role of nutrition in the brain and behavioral development of toddlers and preschool children: identifying and addressing methodological barriers. *Nutritional Neuroscience* 2009;12(5):190–202. doi:10.1179/147683009X423454.
2. Sirikulchayanonta C, Ratanopas W, Temcharoen P, Srisorrachatr S. Self discipline and obesity in Bangkok school children. *BMC Public Health* 2011;11:158. doi: 10.1186/1471-2458-11-158.
3. National Statistical Office of Thailand. Thailand multiple indicator cluster survey (MICS) [internet]. 2021 [Cited 15 February 2025]. Available from: <https://www.unicef.org/thailand/reports/thailand-multiple-indicator-cluster-survey-2019>.
4. Aekplakorn W, Mo-Suwan L. Prevalence of obesity in Thailand. *Obesity Reviews* 2009; 10(6):589–92. doi: 10.1111/j.1467-789X.2009.00626.x. Epub 2009 Jul 28.
5. Ubon Ratchathani Provincial Public Health Office. Maternal and child health performance report, first four months of 2022: Early childhood development and nutrition[report]. Ubon Ratchathani: Ubon Ratchathani Public Health Office. 2022. (in Thai)
6. Khueang Nai District Health Office. Annual nutrition and child development report 2022[report]. Ubon Ratchathani: District Health Office. 2022. (in Thai)
7. Bureau of Nutrition, Ministry of Public Health, Thailand. Guidelines for improving nutrition in child development centers. Bangkok: Ministry of Public Health. 2019. (in Thai)
8. Yoong SL, Lum M, Wolfenden L, Jackson J, Barnes C, Hall AE, et al. Healthy eating interventions delivered in early childhood education and care settings for improving the diet of children aged six months to six years. *Cochrane Database of Systematic Reviews* 2023; Issue 8. doi: 10.1002/14651858.CD013862.pub3.
9. Charoenbut P, Sudathip D. Development of Innovative School Lunch Program to Strengthen Food Security and Nutrition in Child Care Center in Ubon Ratchathani Province [Research report]. Ubon Ratchathani: Ubon Ratchathani Rajabhat University. 2020. (in Thai)
10. Bootsri W, Mungsin S-ard, Ammahia W. Development of local community capacity for food and nutrition to promote community nutrition in Patum areas Ubon Ratchathani. *Journal of Health Science Boromarajonani College of Nursing Sunpasitthiprasong* [internet]. 2023 [cited 15 February];7(3):93–105. Available from: <https://he01.tci-thaijo.org/index.php/bcnsj/article/view/264712>
11. Pinthong T, Charoenbul P, Songserm N. The effect of a food and nutrition management program for preschool children at child development center in Tumbol Rai Noi, Ubon Ratchathani Province. *UBRU Journal for Public Health Research* 2020;9(2):137–147. (in Thai)
12. Kemmis S, McTaggart R, Nixon R. The action research planner: Doing critical participatory action research. Singapore: Springer; 2014.
13. Baum F, MacDougall C, Smith D. Participatory action research. *Journal of Epidemiology and Community Health* 2006;60(10):854–857.



14. Food and Agriculture Organization of the United Nations. FAO school food and nutrition framework [internet]. 2019 [cited 15 February 2025]. Available from: <https://openknowledge.fao.org/server/api/core/bitstreams/6f3162ea-1c1f-4699-a4b1-59a041e5f113/content>.
15. Drake L, Fernandes M, Aurino E, Kiamba J, Giyose B, Burbano C, et al. School feeding programs in middle childhood and adolescence [internet]. 2017 [cited 15 February 2025]. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK525249/>.
16. Van VTS, Siguin CP, Lacsina AC, Yao LF, Sales ZG, Gordoncillo NP, et al. A community-led central kitchen model for school feeding programs in the Philippines: learnings for multisectoral action for health. *Global health: science and practice* 2022;10(6):e2100391. doi:10.9745/GHSP-D-21-00391.
17. World Health Organization. School policy framework: implementation of the WHO global strategy on diet, physical activity and health [internet]. 2008 [cited 15 February 2025]. Available from: <https://iris.who.int/handle/10665/43923>