Food Safety and Balanced Macronutrient and Micronutrient Intake in Children's Health: A Research Protocol

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1. Title Page

Full Title: Food Safety and Balanced Macronutrient and Micronutrient Intake in Children's Health: A Web-Based KAP Intervention Using the NutriAware Platform — A Quasi-Experimental Pre-Post Study

Institutional Affiliation: Faculty of Applied Health Sciences Technology, October 6 University, 6th of October City, Giza, Egypt

Program: Nutrition Technology & Food Safety Program

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IRB Protocol Number: [Pending submission]

Intervention Platform: NutriAware — Malnutrition Intelligence Platform

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2. Abstract

Background: Childhood malnutrition — encompassing undernutrition, micronutrient deficiencies, and overnutrition — remains a formidable global public health challenge. Globally, 150.2 million children under five were stunted, 42.8 million were wasted, and 35.5 million were overweight in 2024. Foodborne diseases further compound the malnutrition burden, with approximately 600 million foodborne illness cases and 420,000 deaths occurring annually, of which 125,000 are children under five. In Egypt, 22.3% of children under five are stunted, 9.5% suffer from wasting, and 15.7% are overweight, alongside a 40% prevalence of iron deficiency anaemia among children aged two to five years. Despite these alarming statistics, integrated research examining the intersection of food safety practices, balanced macronutrient intake, and micronutrient adequacy in the Egyptian context remains scarce.[1][2][3][4][5]. **Aim:** To assess and improve the knowledge, attitudes, and practices (KAP) of caregivers and school-age children regarding food safety, balanced macronutrient intake, and micronutrient adequacy through a structured educational intervention, and to evaluate the effect of such an intervention on dietary quality and anthropometric indicators among children aged 6–12 years in the October 6 University community and surrounding schools. **Methods:** A quasi-experimental pre-post intervention study design will be employed, utilising a **web-based, self-directed digital intervention** delivered through the NutriAware platform, supplemented by illustrated storybooks and printed brochures distributed during school visits. A minimum of 200 caregiver–child dyads will be recruited using stratified random sampling from primary schools in the 6th of October City area. Data collection tools include a validated KAP questionnaire, 24-hour dietary recall, food frequency questionnaire (FFQ), anthropometric measurements (weight, height, BMI-for-age Z-scores using WHO growth standards), and a food safety practices checklist. Caregivers and children will engage with the NutriAware platform content over a 6-week period, guided by weekly WhatsApp reminders and a structured self-learning schedule covering food safety (HACCP-informed), macronutrient balance, and micronutrient adequacy. Pre-intervention (baseline school visit) and post-intervention (6-week follow-up school visit) assessments will be conducted. Data analysis will be performed using SPSS version 28 and R software, employing paired t-tests, chi-square tests, ANOVA, McNemar's test, and multiple regression analyses. Intervention fidelity will be assessed through platform analytics and self-reported engagement measures. Statistical significance will be set at $p < 0.05$. **Expected Outcomes:** Significant improvement in KAP scores related to food safety and balanced nutrition; increased dietary diversity scores; improved micronutrient adequacy (evaluated via the EAR cut-point method); reduced prevalence of unsafe food handling practices; favourable changes in anthropometric indicators; and evidence for the feasibility and effectiveness of a web-based nutrition and food safety intervention platform (NutriAware) for children and caregivers in the Egyptian context.

Keywords: Food safety; macronutrients; micronutrients; KAP; children's health; dietary diversity; malnutrition; Egypt; HACCP; web-based intervention; digital health; NutriAware; mHealth; nutritional intervention

3. Background and Problem Statement

3.1 Global Burden of Childhood Malnutrition

Childhood malnutrition persists as one of the most pressing global health crises, manifesting as a triple burden of undernutrition, micronutrient deficiencies (hidden hunger), and overnutrition. According to the UNICEF–WHO–World Bank Joint Child Malnutrition Estimates (JME) 2025 edition, 150.2 million children under five were stunted (23.2%), 42.8 million were wasted, and 35.5 million were overweight globally in 2024. Progress toward Sustainable Development Goal (SDG) Target 2.2 — ending all forms of malnutrition by 2030 — remains critically insufficient, with only 28% of countries on track to halve child stunting. Save the Children's 2025 analysis revealed that in 20 conflict-affected nations, approximately 44 million children under five — more than one in three — continue to experience stunting, a figure that has not improved since the adoption of the SDGs in 2015. Acute malnutrition (wasting) affected at least 43 million children worldwide in 2024, far exceeding the global target of 32 million.[6][7][8][2]

Malnutrition is directly implicated in nearly half of all deaths in children under five. Beyond mortality, the consequences of chronic malnutrition are lifelong: stunted children suffer from impaired cognitive development, reduced educational attainment, lower economic productivity, and elevated risk of non-communicable diseases (NCDs) in adulthood (Black et al., 2013; Victora et al., 2021). Concurrently, childhood overweight and obesity are escalating rapidly, driven by energy-dense, nutrient-poor diets and sedentary lifestyles, creating a dual burden of malnutrition even within individual households (Popkin et al., 2020).[9]

3.2 Micronutrient Deficiencies in Children

Micronutrient deficiencies — particularly of iron, zinc, vitamin A, and iodine — represent a pervasive yet often invisible dimension of malnutrition. Vitamin A deficiency (VAD) affects an estimated 190 million preschool children globally, with the highest burden in sub-Saharan Africa and South-East Asia. VAD is the leading preventable cause of childhood blindness and substantially increases the risk of severe illness and death from common childhood infections such as diarrhoea and measles. A systematic analysis of the Global Burden of Disease data indicated that children under five in low Socio-Demographic Index (SDI) regions bear a disproportionately high burden of VAD, with prevalence estimates reaching 19.53% in low- and middle-income countries (LMICs).[10][11][12]

Iron deficiency anaemia remains the most prevalent nutritional disorder among children in the Middle East and North Africa (MENA) region. In the MENA region, the prevalence of anaemia in children exceeds 50% in Iraq, Oman, Sudan, and Yemen, while iodine deficiency affects more than 60% of children in Algeria, Morocco, Turkey, and Sudan. Zinc deficiency, though less commonly surveyed, is estimated to affect approximately 17% of the global population and contributes significantly to diarrhoeal disease morbidity and impaired immune function in children (Wessells & Brown, 2012).[13][14]

3.3 Foodborne Illness Burden in Children

Unsafe food constitutes a critical and often underappreciated driver of childhood malnutrition and disease. The WHO estimates that contaminated food causes 600 million cases of foodborne illness and 420,000 deaths each year, resulting in the loss of 33 million Disability-Adjusted Life Years (DALYs) globally. Children under five carry a disproportionate 40% of the foodborne disease burden, despite comprising only 9% of the global population, with approximately 125,000 children in this age group dying annually from foodborne diseases. Diarrhoeal diseases — frequently caused by consumption of food contaminated with norovirus, *Campylobacter*, non-typhoidal *Salmonella*, and pathogenic *E. coli* — are responsible for over half the global burden of foodborne diseases, with 220 million children falling ill and 96,000 dying each year.[15][16][3][1]

The vulnerability of children to foodborne hazards is attributable to their developing immune systems, higher metabolic rate relative to body weight, and dependence on caregivers for food preparation and hygiene practices. Foodborne infections exacerbate malnutrition through a vicious cycle: contaminated food leads to diarrhoeal episodes, which reduce nutrient absorption and increase nutrient losses, further compromising nutritional status and immune function, thereby heightening susceptibility to subsequent infections (Keusch et al., 2022).[17]

3.4 The Egyptian and MENA Regional Context

Egypt presents a particularly instructive case for studying the intersection of food safety and nutritional adequacy. Nutrition is an important public health priority for Egypt, which made significant progress reducing child-stunting rates from 35% in the early 1990s to approximately 20% by 2003. However, this progress reversed, with stunting prevalence climbing to 28.9% (Egypt Demographic and Health Survey [EDHS], 2008) before partially recovering to 22.3% in the most recent estimates. Egypt has the largest number of stunted children in the MENA region — approximately 2.1 million individuals — and its stunting rate is disproportionately high relative to countries with similar levels of economic development. For comparison, Egypt and Jordan have comparable Gross National Incomes, yet the average stunting rate in Egypt (22.3%) is nearly three times that of Jordan (7.8%).[18][4][5]

The prevalence of iron deficiency anaemia among Egyptian children aged two to five years stands at approximately 40%, with longitudinal analyses of the EDHS revealing anaemia prevalence of 37–52% among children aged 12–36 months. The 2014 EDHS further showed that only 8% of children aged 6–59 months received iron supplements in the seven days preceding the survey, and only 2% of children with diarrhoea received zinc treatment. Simultaneously, the prevalence of overweight among Egyptian children under five is 15.7%, substantially higher than the African regional average of 6.0%, with some survey data indicating that approximately one in six (17%) Egyptian children under five are overweight or obese. Child undernutrition alone reduces Egypt's national GDP by approximately 2%, or US$3.7 billion per year.[14][4][5][19][13]

The MENA region at large faces a "triple burden" of malnutrition: the number of undernourished people increased from 16 million in 1990–1992 to 33 million, and overweight and obesity prevalence among adults exceeds 50% in almost all MENA countries. Egypt's National Food Safety Authority has outlined a strategic plan for 2023–2026 aimed at bolstering food safety efforts and enhancing trust in Egyptian food products, with objectives aligned to Egypt's Vision 2030. These national efforts underscore the urgency of research that integrates food safety with nutritional adequacy.[20][13]

3.5 Linking Food Safety Practices to Nutrient Adequacy

The relationship between food safety practices and nutritional outcomes is bidirectional and synergistic. Inadequate food handling, storage, and preparation practices — including failure to maintain cold-chain integrity, cross-contamination between raw and cooked foods, and insufficient cooking temperatures — directly compromise the nutrient content and bioavailability of prepared meals (Grace, 2015). Simultaneously, the resultant foodborne infections deplete micronutrient stores through malabsorption, increased metabolic demand, and enteric losses. A quasi-experimental study in Burkina Faso demonstrated that a 10-month nutrition education intervention targeting maternal food safety KAP significantly improved practices related to cleaning, storage of perishable foods, and cooking thoroughness, with corresponding improvements in dietary diversity. Despite these established links, integrated studies examining food safety practices alongside macronutrient balance and micronutrient adequacy in the Egyptian paediatric context remain exceedingly rare, constituting a critical gap in the literature.[21]

4. Rationale and Significance

4.1 Scientific Importance

This study addresses a fundamental knowledge gap at the intersection of food safety science, nutritional epidemiology, and pediatric public health. While extensive literature examines food safety and nutritional adequacy as separate domains, few studies have adopted an integrated framework that simultaneously evaluates how food safety practices influence nutrient quality and ultimately shape child health outcomes. The application of a KAP-based intervention model to this integrated domain represents a methodological innovation that can generate evidence for both the determinants of, and solutions to, the intertwined challenges of foodborne disease and malnutrition in children. This study will provide empirical data on the EAR cut-point method for evaluating micronutrient adequacy, FAO Dietary Diversity Scoring, and HACCP-informed food safety assessment in a university-community setting, contributing to the methodological toolkit available to researchers in LMICs.

4.2 National Importance for Egypt

Egypt faces a unique nutritional epidemiological profile characterised by persistently high stunting rates despite middle-income economic status, widespread micronutrient deficiencies (particularly iron, vitamin A, and iodine), and rapidly increasing childhood overweight. The Egyptian government's strategic priorities, including the National Food Safety Authority's 2023–2026 plan and alignment with Egypt's Vision 2030, explicitly target improvements in food safety culture, consumer health protection, and nutritional outcomes. Evidence generated by this study will directly inform national nutrition intervention strategies and food safety educational programming.[4][5][14][20]

4.3 Alignment with Sustainable Development Goals

This protocol is directly aligned with SDG 2 (Zero Hunger) specifically Target 2.1 (universal access to safe, nutritious, and sufficient food) and Target 2.2 (ending all forms of malnutrition, including achieving internationally agreed targets on stunting and wasting in children under five). It equally aligns with SDG 3 (Good Health and Well-Being), particularly Target 3.2 (ending preventable deaths of newborns and children under five) and Target 3.9 (reducing deaths and illnesses from hazardous chemicals and contamination). The WHO's Global Nutrition Targets 2030 — including a 40% reduction in stunted children and reduction of wasting to below 5% provide additional normative benchmarks that this study aims to contribute toward.[22][23]

4.4 Gap in Literature

The literature review reveals a notable scarcity of studies that simultaneously integrate food safety hazard assessment (informed by HACCP principles), macronutrient balance evaluation, micronutrient adequacy assessment (using the EAR cut-point method), and dietary diversity scoring (FAO DDS) within a single KAP-based intervention targeting school-age children and their caregivers. Published KAP studies have typically addressed food safety or nutrition knowledge in isolation. This study bridges that gap by adopting a comprehensive, integrated approach informed by both the UNICEF conceptual framework of malnutrition and the food safety risk chain, generating evidence that is directly translatable to policy and practice in Egypt and comparable LMIC settings.[24][25][26]

5. Conceptual Framework

5.1 Theoretical Model

The conceptual framework for this study integrates four complementary theoretical models into a unified analytical structure:

A. The KAP (Knowledge–Attitude–Practice) Model

The KAP model posits that improvements in knowledge lead to favourable attitudinal shifts, which in turn translate into positive behavioural practices (FAO, 2014). In this study, the KAP model is applied bidirectionally: caregivers' and children's knowledge regarding both food safety and balanced nutrition is hypothesised to influence their attitudes toward safe food handling and healthy eating, which subsequently determines food preparation practices, dietary choices, and ultimately child health outcomes. KAP studies have been extensively validated in nutrition research, providing a robust framework for designing and evaluating educational interventions.[27][28]

B. The UNICEF Conceptual Framework of Malnutrition

The UNICEF framework (revised 2020) classifies determinants of malnutrition into three hierarchical levels: immediate causes (inadequate dietary intake and disease), underlying causes (household food insecurity, inadequate care, unhealthy household environments and inadequate health services), and basic causes (societal structures, political and ideological frameworks, economic conditions, and potential resources). This framework acknowledges the triple burden of malnutrition driven by poor diets and poor care services and practices, highlighting the role of diets and care as immediate determinants of maternal and child nutrition.[29][30]

C. The Food Safety Risk Chain

The food safety risk chain traces hazards from food production through processing, distribution, storage, preparation, and consumption. Hazard Analysis and Critical Control Points (HACCP) provides a systematic approach to identifying and controlling biological, chemical, and physical hazards at each stage. In this study, the food safety risk chain is operationalised through household-level assessment of food handling, storage, preparation, and hygiene practices, identifying critical control points where caregiver behaviour directly influences food safety and nutrient preservation.[31]

D. The Nutrient Adequacy Model

Nutrient adequacy is assessed using the Estimated Average Requirement (EAR) cut-point method, which evaluates the proportion of a population with usual intakes below their respective EAR, and the FAO Dietary Diversity Score (DDS), which serves as a proxy indicator for micronutrient adequacy based on the number of distinct food groups consumed.[32][33][34][35]

5.2 Integrated Conceptual Relationships

The integrated framework posits the following causal pathway:

Food Safety Knowledge & Attitudes → Food Safety Practices → Nutrient Quality (reduced contamination, preserved nutrient content, adequate cooking) → Balanced

Macronutrient & Micronutrient Intake → Improved Child Growth & Health Outcomes

Simultaneously, a parallel pathway operates:

Nutrition Knowledge & Attitudes → Dietary Practices (food selection, dietary diversity, meal frequency) → Macronutrient Balance & Micronutrient Adequacy → Improved Anthropometric Indicators

Both pathways are modulated by underlying determinants (household socioeconomic status, caregiver education, access to healthcare) and basic determinants (national food policies, food safety regulations, food system structure). The intervention targets the knowledge and attitude components at the apex of both pathways, with the expectation that improved KAP will cascade through practices to produce measurable improvements in dietary quality and child health indicators.

6. Study Aim

The primary aim of this study is to assess the effectiveness of a structured, KAP-based educational intervention in improving food safety practices, balanced macronutrient intake, and micronutrient adequacy among school-age children (aged 6–12 years) and their caregivers in the 6th of October City community, and to evaluate the resultant impact on children's dietary diversity and anthropometric outcomes.

7. Specific Objectives

7.1 General Objective

To design, implement, and evaluate an integrated educational intervention that enhances food safety awareness and balanced nutritional practices among children and their caregivers, ultimately contributing to improved child health outcomes in the October 6 University community.

7.2 Specific Objectives

1. To assess baseline knowledge, attitudes, and practices (KAP) of caregivers regarding food safety, macronutrient balance, and micronutrient-rich food selection.
2. To assess baseline KAP of school-age children (6–12 years) regarding food safety and healthy eating habits.
3. To evaluate baseline dietary intake patterns of children using 24-hour dietary recall and food frequency questionnaires, with specific emphasis on macronutrient distribution and micronutrient adequacy.
4. To determine baseline anthropometric status of participating children using WHO BMI-for-age Z-scores and height-for-age Z-scores.
5. To design and deliver a 6-week integrated educational intervention addressing food safety practices (informed by HACCP principles), macronutrient balance, micronutrient-rich food promotion, and dietary diversity.

6. To evaluate post-intervention changes in KAP scores among caregivers and children, comparing pre- and post-intervention measurements.
7. To assess post-intervention changes in children's dietary diversity scores (FAO DDS methodology) and micronutrient adequacy (EAR cut-point method).
8. To evaluate post-intervention changes in children's anthropometric indicators (weight, height, BMI-for-age Z-score).
9. To identify sociodemographic and behavioural predictors of food safety knowledge, dietary diversity, and micronutrient adequacy among the study population.
10. To examine the association between food safety practice scores and dietary quality indicators (dietary diversity, macronutrient balance, micronutrient adequacy) in children.

8. Research Questions

1. What is the baseline level of knowledge, attitudes, and practices regarding food safety among caregivers of school-age children in the 6th of October City community?
2. What is the baseline level of KAP regarding food safety and healthy eating among school-age children aged 6–12 years?
3. What is the prevalence of macronutrient imbalance and micronutrient inadequacy (iron, zinc, vitamin A, iodine, calcium) among children aged 6–12 years in the study population?
4. What is the prevalence of stunting, wasting, underweight, overweight, and obesity (based on WHO BMI-for-age and height-for-age Z-scores) among children in the study population?
5. Does the 6-week integrated educational intervention produce a statistically significant improvement in caregiver KAP scores related to food safety and balanced nutrition?
6. Does the intervention lead to a significant increase in children's dietary diversity scores and micronutrient adequacy as assessed by the EAR cut-point method?
7. Is there a significant association between food safety practice scores and dietary quality indicators (dietary diversity, macronutrient balance, micronutrient adequacy)?
8. What sociodemographic factors (caregiver education, income, household size, employment status) are significantly associated with food safety KAP and children's dietary quality?
9. Does improved caregiver food safety knowledge correlate with reduced prevalence of reported foodborne illness episodes in children?
10. Are post-intervention improvements in KAP scores associated with favourable changes in children's anthropometric Z-scores?

9. Methodology

9.1 Study Design

This study employs a **quasi-experimental pre-post intervention design** with a single-group design and repeated measurements (baseline at Week 0 and post-intervention at Week 6). The intervention is delivered through a **web-based, self-directed digital platform (NutriAware)** supplemented by printed educational materials (illustrated storybooks and brochures) distributed during school visits. This digital intervention approach is justified by growing evidence that web-based and mobile health (mHealth) nutrition interventions are effective in improving dietary knowledge, attitudes, and behaviors among children and their caregivers. A 2025 systematic review of 34 studies found that 68% of mobile- and web-based dietary interventions reported positive outcomes on at least one measured variable, with improvements in nutrition knowledge reported in 68% of studies and improvements in fruit intake in 50%. A quasi-experimental study in Turkey demonstrated that web-based nutrition education for parents of preschool children significantly reduced nutritional risk, with 94.2% of children classified as low risk at 1-month follow-up compared to only 44.2% at baseline. The pre-post design allows each participant to serve as their own control, with statistical analysis comparing within-subject changes over the 6-week exposure period. This design has been successfully employed in comparable web-based and KAP-based nutritional interventions in school settings.[36][37][38][39][40]

9.2 Study Setting

The study will be conducted in primary schools in 6th of October City, Giza Governorate, Egypt, within the October 6 University community catchment area. This setting is justified on the following grounds:

- **Accessibility:** Proximity to October 6 University facilitates logistical coordination, ethical oversight, and researcher access. School visits are required only twice (baseline and post-intervention), minimising logistical burden.
- **Population representativeness:** The 6th of October City community encompasses families from diverse socioeconomic backgrounds, including both urban and peri-urban households, reflecting the broader Egyptian demographic profile.
- **Digital infrastructure:** The study area has adequate internet and smartphone penetration to support a web-based intervention delivered through the NutriAware platform. Egypt's internet penetration rate exceeds 72%, and smartphone ownership among urban households is high, making digital health interventions feasible.
- **Institutional support:** October 6 University's Faculty of Applied Health Sciences Technology provides the institutional infrastructure, laboratory resources, and trained personnel necessary for anthropometric assessment and dietary data analysis.
- **Policy relevance:** The study setting aligns with Egypt's National Food Safety Authority strategic plan for 2023–2026, which emphasises community-based food safety education and awareness.[20]

9.3 Study Population

Target population: Children aged 6–12 years enrolled in primary schools within the 6th of October City area, and their primary caregivers.

Inclusion criteria:

- Children aged 6–12 years enrolled in participating primary schools
- Apparently healthy children without diagnosed chronic diseases affecting growth or nutrient metabolism
- Primary caregiver willing to provide informed consent and participate in the educational intervention
- Caregiver responsible for the child's food preparation at least 5 days per week
- Residents of 6th of October City for at least 6 months prior to enrolment

Exclusion criteria:

- Children with diagnosed chronic illnesses (e.g., coeliac disease, inflammatory bowel disease, cystic fibrosis, congenital heart disease) that independently affect nutritional status
- Children on therapeutic diets or medical nutrition therapy
- Children with physical disabilities precluding accurate anthropometric measurement
- Caregivers unable to communicate in Arabic
- Families planning to relocate during the study period

9.4 Sample Size Calculation

The sample size is calculated using the formula for comparing two paired means (pre- and post-intervention) in a single-group design:[41][42]

$$n = \frac{(Z_{1-\alpha/2} + Z_{1-\beta})^2 \times \sigma_d^2}{d^2}$$

Where:

- $Z_{1-\alpha/2}$ = 1.96 (for a two-sided test at α = 0.05)
- $Z_{1-\beta}$ = 0.84 (for 80% statistical power)
- σ_d = estimated standard deviation of the difference in KAP scores between pre- and post-intervention (estimated at 12 points based on comparable studies)
- d = minimum clinically meaningful difference to detect (set at 5 points on the KAP scale, based on prior literature)

Calculation:

$$n = \frac{(1.96 + 0.84)^2 \times 12^2}{5^2} = \frac{(2.80)^2 \times 144}{25} = \frac{7.84 \times 144}{25} = \frac{1128.96}{25} = 45.16$$

Rounding up: n = 46 per comparison subgroup. Considering a design effect of 1.5 for cluster sampling (school-level clustering) and a 20% anticipated dropout rate:

$$n_{adjusted} = \frac{46 \times 1.5}{1 - 0.20} = \frac{69}{0.80} = 86.25 \approx 87$$

To ensure adequate statistical power across stratified subgroups (by age, sex, socioeconomic status) and for multivariate regression analyses, the total sample is increased to a minimum of **200 caregiver–child dyads** (i.e., 200 children and 200 corresponding primary caregivers). This sample size is consistent with recommendations for quasi-experimental nutritional intervention studies in school settings.[43][41]

9.5 Sampling Technique

Stratified random sampling will be employed through the following steps:

1. **Stage 1 — School selection:** A list of all primary schools within the 6th of October City administrative boundary will be obtained from the local educational directorate. Schools will be stratified by type (public vs. private) and geographic zone. A proportional random sample of 4–6 schools will be selected.
2. **Stage 2 — Class selection:** Within each selected school, classes will be stratified by grade level (grades 1–6, corresponding to ages 6–12). One class per grade level will be randomly selected.
3. **Stage 3 — Participant selection:** All eligible children within selected classes will be invited to participate with their primary caregivers. If enrolment exceeds the target sample for a given stratum, simple random sampling will be used to select participants.

This sampling strategy ensures representation across age groups, socioeconomic levels, and school types, enhancing the generalisability of findings within the study area.

10. Data Collection Tools

10.1 Structured KAP Questionnaire

A comprehensive KAP questionnaire will be developed based on established instruments, including the FAO guidelines for assessing nutrition-related KAP, the WHO Five Keys to Safer Food, and validated KAP tools from published literature. The questionnaire will comprise four sections:[25][28][27]

- **Section A — Sociodemographic characteristics:** Caregiver age, sex, education level, employment status, household income, household size, child's age, sex, birth order.
- **Section B — Knowledge:** 30 items assessing knowledge of food safety principles (hand hygiene, cross-contamination, safe cooking temperatures, food storage), macronutrient functions and sources, micronutrient importance (iron, zinc, vitamin A, iodine, calcium), and age-appropriate dietary requirements. Items scored as correct (1) or incorrect/unsure (0). Total range: 0–30.

- **Section C — Attitudes:** 20 items assessed on a 5-point Likert scale (strongly disagree = 1 to strongly agree = 5) measuring attitudes toward food safety practices, healthy eating habits, importance of dietary diversity, and willingness to adopt recommended practices. Total range: 20–100.
- **Section D — Practices:** 20 items assessing self-reported food safety behaviours and dietary practices on a frequency scale (never = 1, rarely = 2, sometimes = 3, often = 4, always = 5). Total range: 20–100.

Overall KAP scores will be categorised using Bloom's cut-off points: Good (80–100%), Moderate (60–79%), Poor (<60%).[25]

10.2 24-Hour Dietary Recall

A standardised 24-hour dietary recall will be administered to caregivers (as proxies for children aged 6–9 years) and directly to children aged 10–12 years with caregiver verification. The multiple-pass method (five-step) will be used to enhance recall accuracy (Gibson, 2005). Dietary data will be collected on two non-consecutive days (one weekday and one weekend day) at each assessment point (pre- and post-intervention) to account for day-to-day variability. Nutrient intake will be calculated using the Egyptian food composition database and NutriSurvey software. Macronutrient intake will be expressed as percentages of total energy from carbohydrates, protein, and fat, and compared to Acceptable Macronutrient Distribution Ranges (AMDR).

10.3 Food Frequency Questionnaire (FFQ)

A semi-quantitative FFQ adapted for the Egyptian dietary context will assess habitual intake frequency of key food groups over the preceding month. The FFQ will include 80–100 food items grouped into categories aligned with the FAO Dietary Diversity Score food groups: (1) grains, white roots and tubers; (2) pulses; (3) nuts and seeds; (4) dairy; (5) meat, poultry, and fish; (6) eggs; (7) dark green leafy vegetables; (8) other vitamin A-rich fruits and vegetables; (9) other vegetables; (10) other fruits. Frequency response options: never or less than once/month, 1–3 times/month, once/week, 2–4 times/week, 5–6 times/week, once/day, 2+ times/day.

10.4 Anthropometric Measurements

Anthropometric measurements will be obtained by trained research assistants following WHO standardised protocols:

- **Weight:** Measured to the nearest 0.1 kg using a calibrated digital scale (SECA 874), with children wearing light clothing and no shoes.
- **Height:** Measured to the nearest 0.1 cm using a portable stadiometer (SECA 213), with children standing erect, heels together, and head in the Frankfurt plane.
- **BMI calculation:** $\text{BMI} = \text{weight (kg)}/\text{height (m)}^2$

Z-score classifications based on WHO Growth Standards (for children aged 5–19 years):[44][45]

Indicator	Classification	Z-score

Height-for-age	Severe stunting	< −3
Height-for-age	Stunting	< −2
BMI-for-age	Severe thinness	< −3
BMI-for-age	Thinness	< −2
BMI-for-age	Overweight	> +1
BMI-for-age	Obesity	> +2

Z-scores will be computed using the WHO AnthroPlus software (version 1.0.4) for children aged 5–19 years.[46]

10.5 Food Safety Practices Checklist

A structured observational checklist based on HACCP principles and the WHO Five Keys to Safer Food will assess household food safety practices. The checklist will cover:[47][31]

- **Keep clean:** Handwashing frequency and technique, kitchen surface sanitation, utensil cleanliness.
- **Separate raw and cooked:** Use of separate cutting boards, storage separation, prevention of cross-contamination.
- **Cook thoroughly:** Internal temperature monitoring, adequate cooking of meat/poultry/eggs.
- **Keep food at safe temperatures:** Refrigerator temperature maintenance (≤5°C), hot-holding practices (≥60°C), cooling procedures, time in the temperature danger zone (5–60°C) limited to <4 hours.[48]
- **Use safe water and raw materials:** Water source and treatment, freshness of produce, expiry date checking, food labelling awareness.

Each item is scored on a compliance scale (fully compliant = 2, partially compliant = 1, non-compliant = 0), yielding a composite food safety practice score.

10.6 Validity and Reliability

Content validity: The KAP questionnaire, FFQ, and food safety checklist will be reviewed by a panel of five experts (two in public health nutrition, one in food safety, one in paediatrics, one in epidemiology) from October 6 University and affiliated institutions. The Content Validity Index (CVI) will be calculated; items with CVI < 0.80 will be revised or eliminated.[27]

Face validity: The instruments will be reviewed by a sample of 10 caregivers (not included in the main study) for clarity, cultural appropriateness, and comprehension.

Construct validity: Exploratory factor analysis (EFA) will be conducted on the KAP questionnaire using pilot study data (n = 30) to confirm the underlying factor structure.

Reliability: Internal consistency will be assessed using Cronbach's alpha, with a threshold of $\alpha \geq 0.70$ considered acceptable for each subscale. Test-retest reliability will be evaluated using the intraclass correlation coefficient (ICC) on a subsample of 30 participants at a 2-week interval; ICC $\geq$ 0.75 will be considered satisfactory.[27]

Pilot testing: The complete data collection package will be pilot-tested on 30 caregiver–child dyads from a non-participating school to evaluate instrument feasibility, time requirements (target: ≤45 minutes total), and data collection logistics. Results will inform final instrument refinements before main study commencement.

11. Variables

11.1 Independent Variables

- **Intervention exposure** (primary independent variable): pre-intervention vs. post-intervention
- Caregiver sociodemographic characteristics: age, sex, education level, occupation, monthly household income, household size, marital status
- Child sociodemographic characteristics: age, sex, birth order, school type (public/private)
- Caregiver food safety knowledge score
- Caregiver nutrition knowledge score
- Caregiver attitude scores (food safety and nutrition)

11.2 Dependent Variables

- Caregiver KAP scores (knowledge, attitude, practice — individually and composite)
- Child KAP scores (knowledge and practice)
- Child dietary diversity score (FAO DDS — number of food groups consumed in previous 24 hours)
- Child macronutrient intake (% energy from carbohydrates, protein, fat)
- Child micronutrient adequacy (proportion meeting EAR for iron, zinc, vitamin A, iodine, calcium)
- Child anthropometric indicators: BMI-for-age Z-score, height-for-age Z-score, weight-for-age Z-score
- Food safety practice score (composite checklist score)
- Reported foodborne illness episodes in children (past 2 weeks)

11.3 Confounding Variables

- Caregiver educational level
- Household socioeconomic status / income
- Access to healthcare services
- Household food security status
- Number of children in household
- Caregiver nutritional status (BMI)
- Child's baseline health status
- Seasonal variation in food availability
- Media exposure to nutrition/food safety information
- Water source and sanitation quality

12. Intervention Plan

12.1 Intervention Overview

The educational intervention is a **6-week, web-based, self-directed programme** delivered primarily through the NutriAware digital platform (https://nutriaware.info), supplemented by printed educational materials (illustrated storybooks and brochures) distributed during the baseline school visit. This approach leverages the established effectiveness of digital health interventions for nutrition education in children, which have been shown to improve dietary knowledge in 68% of intervention studies and promote healthier food choices. Unlike traditional face-to-face session-based programmes, the web-based self-directed model allows caregivers and children to engage with educational content at their own pace, in their home environment, and at times convenient to their schedules — a critical advantage in contexts where repeated school visits are logistically constrained.[38][40][49]

12.2 Intervention Components

The intervention content mirrors the thematic scope of a comprehensive face-to-face programme but is delivered entirely through digital and print channels:

Component A — NutriAware Digital Platform

The NutriAware platform serves as the primary intervention tool, providing caregivers and children with:

- **Food Safety Education Module:** Interactive content covering the WHO Five Keys to Safer Food; HACCP principles simplified for household application — identifying biological hazards (bacteria, viruses, parasites), chemical hazards (pesticide residues, aflatoxins), and physical hazards; critical control points in home food preparation (purchasing, storage, preparation, cooking, serving, leftover management); safe food storage and cross-contamination prevention.[31]
- **Balanced Macronutrient Intake Module:** Educational content on macronutrient functions, sources, and age-appropriate requirements; practical meal planning for balanced macronutrient distribution (AMDR: 45–65% carbohydrates, 10–30%

protein, 25–35% fat for children aged 4–18 years); healthy snacking strategies; food label reading guidance.[50]

- **Micronutrient Adequacy & Dietary Diversity Module:** Content on key micronutrients — iron (sources: liver, legumes, dark leafy greens), zinc (meat, seeds, legumes), vitamin A (liver, orange/yellow fruits and vegetables, dark green leafy vegetables), iodine (iodised salt), and calcium (dairy, small fish with bones); FAO Dietary Diversity Score principles; strategies for enhancing dietary diversity on limited budgets.[33][35]
- **Personalised Nutrition Planning Tool:** An interactive feature allowing caregivers to create personalised dietary plans for their children based on age, weight, and nutritional needs, integrating food safety considerations into meal planning.

Component B — Illustrated Storybooks for Children

Age-appropriate illustrated storybooks featuring engaging characters navigating food safety and nutrition scenarios will be distributed to all participating children during the baseline school visit. The storybooks cover:

- Food safety hygiene (handwashing, clean kitchen practices)
- The food group adventure (exploring macronutrients and micronutrients)
- The balanced plate (building healthy meals)
- Safe food preparation (HACCP principles in child-friendly narrative form)

Component C — Printed Brochures for Caregivers

Take-home brochures summarising key messages will be distributed at baseline, including:

- Quick-reference guide to the WHO Five Keys to Safer Food
- Weekly meal planning templates with balanced macronutrient and micronutrient guidance
- QR code and direct link to the NutriAware platform for continued engagement
- Contact information for the research team for questions

Component D — Digital Reinforcement (WhatsApp Group)

A dedicated WhatsApp group will be established for participating caregivers, through which the research team will send:

- Weekly reminder messages encouraging platform use (Weeks 1–6)
- Weekly nutrition tips and food safety infographics
- Encouragement to explore specific sections of the NutriAware platform each week
- Responses to caregiver questions

12.3 Weekly Engagement Schedule

To structure self-directed learning and ensure content coverage equivalent to a session-based programme, caregivers will receive a guided weekly plan:

Week	Recommended NutriAware Platform Focus	Supplementary Materials
Week 1	Food safety foundations — WHO Five Keys; handwashing; kitchen hygiene	Storybook Chapter 1; Brochure Section A
Week 2	HACCP at home — safe storage, cooking temperatures, cross-contamination	Storybook Chapter 2
Week 3	Macronutrients — understanding carbohydrates, proteins, fats; meal balance	Storybook Chapter 3; Brochure Section B
Week 4	Practical meal planning — using the personalised nutrition planning tool	WhatsApp: meal planning template
Week 5	Micronutrients — iron, zinc, vitamin A, iodine, calcium; food sources	Storybook Chapter 4; Brochure Section C
Week 6	Dietary diversity — building diverse meals; integration of food safety + nutrition	WhatsApp: summary infographic

12.4 Delivery Methods

- **Self-directed web-based learning:** Caregivers and children access the NutriAware platform independently from home using smartphones, tablets, or computers. This approach is supported by evidence showing that web-based nutrition interventions are as effective as, and sometimes superior to, face-to-face delivery for improving nutrition knowledge.[51][38]
- **Story-based learning for children:** Illustrated storybooks distributed at baseline provide a non-digital, engaging learning medium suitable for younger children and households with limited internet access.
- **Printed brochures:** Serve as a quick-reference complement to the digital platform and ensure key messages are accessible offline.
- **WhatsApp reinforcement:** Weekly messages maintain engagement and guide participants through the structured content over the 6-week period, functioning as a low-cost, scalable form of intervention fidelity monitoring.[52]

12.5 Intervention Duration and Timeline

The intervention spans **6 weeks** of self-directed engagement with the NutriAware platform, storybooks, and brochures, beginning immediately after the baseline school visit. Post-intervention assessment (second school visit) will be conducted at **Week 6** following baseline. The total participant contact involves only **two school visits** (baseline and post-intervention), with all educational content delivered remotely through the platform and printed materials.

12.6 Intervention Fidelity Monitoring

To assess and ensure adequate exposure to the intervention:

- **Platform analytics:** The NutriAware website will track page views, unique visitors, time spent on each module, and feature usage (e.g., personalised nutrition planning tool) using embedded analytics (Google Analytics or equivalent).
- **WhatsApp engagement:** Message read receipts and caregiver responses will be logged.
- **Self-reported exposure:** The post-intervention questionnaire will include items assessing frequency of platform visits, sections accessed, storybook reading frequency, and brochure use.
- **Dose-response analysis:** Statistical analysis will examine whether the degree of platform engagement (measured by self-reported visits and analytics data) is associated with the magnitude of KAP improvement, enabling a dose-response evaluation.

15. Ethical Considerations

15.1 Informed Consent

Written informed consent will be obtained from all participating caregivers prior to enrolment. A simplified information sheet (in Arabic) will explain the study purpose, procedures, risks, benefits, confidentiality measures, and the right to withdraw at any time without penalty. For children aged 10–12 years, a child-friendly assent form will be provided. Parental consent will be required for all children regardless of age. Verbally recorded consent in the presence of a witness will be available for illiterate participants.[25]

15.2 Institutional Review Board (IRB) Approval

The study protocol, informed consent documents, data collection instruments, and intervention materials will be submitted for review and approval to the Research Ethics Committee (REC) of October 6 University's Faculty of Applied Health Sciences Technology prior to any participant recruitment or data collection. No study activities will commence until full ethical approval is obtained.

15.3 Confidentiality and Data Protection

- All participant data will be coded using unique alphanumeric identifiers; names and personal identifiers will be stored separately from research data in a password-protected file accessible only to the principal investigator.
- Electronic data will be stored on encrypted, password-protected computers with regular backups to a secure institutional server.
- Hard-copy forms will be stored in locked filing cabinets within a secured office at the university.
- All data will be retained for a minimum of 5 years following study completion, after which it will be securely destroyed.
- Data analysis will use anonymised datasets only.

15.4 Risk Minimisation

The study poses minimal risk to participants. Anthropometric measurements are non-invasive and performed using standard clinical techniques. Dietary assessments rely on self-report and do not involve any biological specimen collection. The educational intervention involves evidence-based nutrition and food safety information consistent with national and international guidelines (WHO, FAO, Egyptian National Nutrition Institute). Any child identified with severe malnutrition (Z-score < −3) or other health concerns during anthropometric assessment will be referred to appropriate healthcare services.

15.5 Benefits

Participants will directly benefit from enhanced knowledge and skills related to food safety and balanced nutrition. Children identified with nutritional concerns will receive referrals to healthcare providers. Participating schools will receive food safety and nutrition educational materials for continued use. Aggregate results will be shared with school administrators and local health authorities to inform community-level nutrition programming.

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16. Expected Outcomes

1. **Improved knowledge scores:** Significant increase (≥15% improvement) in mean caregiver and child knowledge scores related to food safety, macronutrient balance, and micronutrient-rich food selection.
2. **Positive attitudinal shift:** Significant improvement in attitudes toward food safety practices and healthy eating, measured by Likert-scale attitudinal items.
3. **Improved dietary practices:** Significant increase in mean Dietary Diversity Scores (from an expected baseline of ~3.5 to ≥5 food groups post-intervention), reflecting improved dietary quality.
4. **Enhanced micronutrient adequacy:** Reduction in the proportion of children with micronutrient intakes below the EAR for iron, zinc, vitamin A, and calcium.
5. **Reduced unsafe food practices:** Significant improvement in composite food safety practice scores, with increased compliance with WHO Five Keys and HACCP-informed household food safety behaviours.
6. **Favourable anthropometric trends:** Modest but measurable improvement in BMI-for-age Z-scores (reduced prevalence of both underweight and overweight) and height-for-age Z-scores.
7. **Evidence for policy:** Generation of actionable, context-specific evidence to inform Egypt's national food safety and nutrition education strategies.
8. **Methodological contribution:** Demonstration of an integrated KAP-based intervention model that can be replicated in comparable LMIC settings.

17. Timeline (Gantt Chart Format)

Activity	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8
Literature review & protocol finalisation	■	■						
Ethical approval (IRB submission & review)	■	■						
Instrument development & expert validation		■	■					
Pilot testing & instrument refinement			■					
School recruitment & participant enrolment			■	■				
Baseline data collection (pre-intervention)				■				
Intervention delivery (6 weeks)				■	■			
Post-intervention data collection					■			
Data entry, cleaning & quality assurance					■	■		
Statistical analysis						■	■	
Report writing & manuscript preparation							■	■
Dissemination (conference/journal submission)								■

21. References

The following references are cited in APA 7th edition format. In-text citations throughout the protocol follow APA style. All sources are from 2015–2026 unless otherwise indicated for foundational works.

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