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Systematic Review of Ready-to-Use Therapeutic Food Effectiveness for Treatment of Severe Childhood Malnutrition

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Abstract
Severe acute malnutrition remains one of the most pressing public health challenges affecting children under five years of age in low- and middle-income countries, contributing significantly to childhood morbidity and mortality rates globally. Ready-to-use therapeutic food has emerged as a revolutionary intervention strategy that enables home-based management of severe malnutrition, thereby reducing the burden on healthcare facilities while improving treatment accessibility for vulnerable populations (Uddoh *et al*., 2021a). This systematic review critically examines the effectiveness, safety, acceptability, and implementation strategies of ready-to-use therapeutic food interventions across diverse geographical and socioeconomic contexts. The review synthesizes evidence from multiple studies that have evaluated nutritional recovery rates, weight gain velocities, treatment completion rates, and relapse prevention outcomes among severely malnourished children receiving ready-to-use therapeutic food compared to traditional facility-based therapeutic feeding programs. Findings indicate that ready-to-use therapeutic food demonstrates comparable or superior efficacy to standard therapeutic approaches while offering significant advantages in terms of cost-effectiveness, family convenience, and community-level scalability (Schoonees *et al*., 2013). However, implementation challenges persist, including supply chain constraints (Bukhari *et al*., 2021a), cultural acceptability issues (Umekwe & Oyedele, 2021), quality assurance concerns (Okonkwo & Onasanya, 2021), and the need for integrated community health worker training programs (Komi *et al*., 2021a). The review also explores the role of locally produced ready-to-use therapeutic food formulations in enhancing sustainability and cultural appropriateness of malnutrition treatment programs (Thapa *et al*., 2017). Furthermore, this analysis examines the intersection of ready-to-use therapeutic food interventions with broader health system strengthening initiatives (Oluoha *et al*., 2021), vaccination programs (Piot *et al*., 2019), maternal health services (Mustapha *et al*., 2021), and poverty alleviation strategies that address the underlying determinants of childhood malnutrition (Ruel *et al*., 2018). The findings underscore the importance of adopting holistic, community-centered approaches that combine nutritional interventions with health education, economic empowerment, and environmental health improvements to achieve sustainable reductions in severe acute malnutrition prevalence. This review contributes to the growing body of evidence supporting the integration of ready-to-use therapeutic food into national nutrition policies and community health programs as a cornerstone intervention for achieving global nutrition and child survival targets.

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1. Introduction

Severe acute malnutrition represents a critical global health emergency that affects millions of children annually, particularly in resource-limited settings where access to healthcare services remains inadequate and socioeconomic vulnerabilities are pervasive (Ojeikere *et al*., 2021a). The condition is characterized by severe wasting, defined as weight-for-height below negative three standard deviations from the median, or by the presence of bilateral pitting edema, and is associated with profound physiological and immunological impairments that substantially increase the risk of infectious diseases and death (de Onis & Blössner, 1997).

Traditional approaches to managing severe acute malnutrition have relied heavily on facility-based therapeutic feeding programs that require prolonged hospitalization, thereby creating significant barriers to treatment access for families living in remote rural areas or conflict-affected regions where health infrastructure is limited or non-existent (Komi *et al*., 2021b). The introduction of ready-to-use therapeutic food in the early 2000s marked a paradigm shift in malnutrition treatment strategies by enabling effective home-based management of uncomplicated severe acute malnutrition cases, thus dramatically expanding treatment coverage while reducing healthcare costs and family burden (Ciliberto *et al*., 2005).

Ready-to-use therapeutic food is a nutrient-dense, lipid-based paste that requires no preparation, has a long shelf life without refrigeration, and is designed to provide complete nutritional support for severely malnourished children (Awuchi *et al*., 2020; Okonkwo *et al*., 2021b). The standard formulation typically contains peanut paste, vegetable oil, milk powder, sugar, and a vitamin-mineral complex that delivers approximately 500 kilocalories per 92-gram sachet, meeting the elevated energy and micronutrient requirements of children recovering from severe malnutrition (Schoonees *et al*., 2013). The effectiveness of ready-to-use therapeutic food has been demonstrated across multiple geographical contexts, with studies showing nutritional recovery rates exceeding 75 percent and low mortality rates among children treated in community-based programs, outcomes that are comparable to those achieved in facility-based settings while offering substantial advantages in terms of cost-effectiveness and family convenience (Gera, 2010; Okonkwo *et al*., 2021a). However, the success of ready-to-use therapeutic food interventions depends critically on multiple factors including product quality, supply chain reliability (Bukhari *et al*., 2021a), community health worker competence (Umar *et al*., 2021), caregiver adherence, and the integration of nutritional treatment with broader health system services such as vaccination, deworming, and management of concurrent infections (Adenuga & Okolo, 2021).

The global burden of severe acute malnutrition is inextricably linked to broader patterns of poverty, food insecurity, poor sanitation, inadequate maternal and child health services, and limited educational opportunities that perpetuate cycles of malnutrition across generations (Alderman & Garcia, 1994). Economic analyses have consistently demonstrated that undernutrition during early childhood has profound long-term consequences for physical growth, cognitive development, educational attainment, and economic productivity, thereby reinforcing intergenerational poverty traps and constraining national development trajectories (Thomas & Strauss, 1997). The relationship between economic development and nutritional status is complex and bidirectional, with evidence suggesting that while economic growth can contribute to reductions in malnutrition prevalence, the pathways through which growth translates into improved nutritional outcomes are mediated by multiple factors including income distribution, public health infrastructure, agricultural productivity, and social protection systems (Smith & Haddad, 2002). Understanding these complex interactions is essential for designing comprehensive nutrition interventions that address both immediate nutritional deficits and the underlying structural determinants of malnutrition.

The geographic distribution of severe acute malnutrition exhibits pronounced disparities, with the highest burden concentrated in sub-Saharan Africa and South Asia, regions characterized by high poverty rates, recurrent food crises, armed conflicts, and weak health systems that struggle to deliver essential nutrition and health services to vulnerable populations (Lopez *et al*., 2006). Urban-rural disparities in child health outcomes have been extensively documented, although recent evidence suggests that urban advantages in nutritional status may be diminishing as rapid urbanization creates pockets of extreme poverty in informal settlements where children face multiple environmental health hazards including poor sanitation, overcrowding, and limited access to clean water and healthcare services (Van de Poel *et al*., 2007). The household-level determinants of child malnutrition include food insecurity, inadequate infant and young child feeding practices, poor maternal nutritional status and health, limited access to clean water and sanitation, and inadequate healthcare seeking behavior, all of which are influenced by broader community-level factors such as food availability, healthcare infrastructure, educational levels, and social norms regarding childcare and nutrition (Fotso & Kuate-Defo, 2005; Bukhari *et al*., 2021b).

Environmental factors play a significant role in shaping patterns of childhood malnutrition, with evidence from Ethiopia and other settings demonstrating that ecological degradation, climate variability, and agricultural production failures contribute substantially to food insecurity and nutritional vulnerability among rural populations dependent on subsistence farming (Silva, 2005; Taiwo *et al*., 2021). The paradox of double burden malnutrition, characterized by the coexistence of undernutrition and overweight or obesity within the same populations or even within the same households, has emerged as an important public health challenge in middle-income countries undergoing nutrition transition, reflecting complex changes in dietary patterns, physical activity levels, and food environments (Kimani-Murage, 2013). This epidemiological transition necessitates integrated policy responses that simultaneously address undernutrition and diet-related chronic diseases through comprehensive food system transformations and health promotion strategies (Didi *et al*., 2021).

The life course perspective on nutrition emphasizes that adequate nutrition during critical periods of growth and development, particularly the first 1000 days from conception to age two years, has profound and largely irreversible effects on physical stature, cognitive capacity, and disease susceptibility throughout the lifespan (Perkins *et al*., 2016). Maternal malnutrition and poor health during pregnancy contribute to low birth weight and intrauterine growth restriction, which substantially increase the risk of neonatal mortality and subsequent childhood malnutrition, thereby establishing intergenerational cycles of growth failure that persist across generations (Martorell *et al*., 1995). Breaking these cycles requires comprehensive continuum of care approaches that integrate preconception nutrition, antenatal care, skilled birth attendance, immediate newborn care, exclusive breastfeeding promotion, timely introduction of complementary foods, and management of childhood illnesses and malnutrition (Kerber *et al*., 2007).

The role of health systems in preventing and treating childhood malnutrition extends beyond direct nutrition interventions to encompass immunization services (Abdulkarim *et al*., 2011), growth monitoring and promotion, micronutrient supplementation, treatment of infectious

diseases, maternal health services, and health education activities that collectively contribute to improved nutritional outcomes (Warren *et al*., 2013). Community-based approaches to health service delivery have demonstrated particular promise for reaching underserved populations with essential nutrition and health interventions, with evidence from Ghana and other settings showing that trained community health workers can effectively manage uncomplicated cases of severe acute malnutrition using ready-to-use therapeutic food while appropriately referring complicated cases to health facilities (Phillips *et al*., 2006; Aduwo *et al*., 2021a). The integration of nutrition interventions within comprehensive primary healthcare platforms enables synergistic effects whereby improved nutrition enhances the effectiveness of other health interventions such as vaccination, while better health status contributes to improved nutritional outcomes (Longlett *et al*., 2001; Frempong *et al*., 2021).

Policy frameworks for addressing malnutrition must be multisectoral in nature, engaging stakeholders across health, agriculture, education, social protection, water and sanitation, and economic development sectors in coordinated efforts to address the multiple determinants of nutritional status (Ruel *et al*., 2018; Akinboboye *et al*., 2021). The increasing recognition of nutrition as a critical foundation for human capital development and economic growth has catalyzed greater political commitment and resource allocation to nutrition programs in many countries, although significant implementation gaps persist between policy commitments and actual service delivery at the community level (Sanusi *et al*., 2021; Umoren *et al*., 2021b). This systematic review aims to synthesize the available evidence on ready-to-use therapeutic food effectiveness, identify best practices for implementation, and highlight remaining knowledge gaps and research priorities that should guide future efforts to scale up community-based management of severe acute malnutrition as a core component of comprehensive child survival and nutrition strategies.

2. Literature Review

The evolution of therapeutic feeding approaches for severe acute malnutrition reflects broader shifts in understanding the pathophysiology of malnutrition, the recognition of community-level determinants of nutritional status, and the development of innovative nutrition products and delivery strategies that enable decentralized treatment models. Early approaches to malnutrition management emphasized facility-based therapeutic feeding using milk-based formulas that required careful preparation and posed significant risks of contamination and incorrect dilution, necessitating close medical supervision and prolonged hospitalization that created substantial barriers to treatment access and imposed heavy burdens on both health systems and affected families (Ciliberto *et al*., 2005; Umoren *et al*., 2021c). The recognition that most severe acute malnutrition cases are uncomplicated and do not require intensive medical management led to the exploration of home-based treatment approaches that could dramatically expand treatment coverage while reducing costs, but implementation of home-based treatment using traditional therapeutic milk formulas remained challenging due to preparation requirements and cold chain dependencies.

The development of ready-to-use therapeutic food represented a breakthrough innovation that addressed many of the practical limitations of earlier therapeutic feeding approaches by providing a shelf-stable, ready-to-consume product that could be safely administered at home with minimal risk of contamination (Schoonees *et al*., 2013; Balogun *et al*., 2021b). Controlled clinical trials conducted in Malawi demonstrated that children treated at home with ready-to-use therapeutic food achieved recovery rates, weight gain velocities, and mortality outcomes comparable to those of children receiving facility-based treatment with standard therapeutic milk formulas, while experiencing shorter treatment duration and lower rates of treatment default (Ciliberto *et al*., 2005; Umoren *et al*., 2019). These findings established the efficacy of ready-to-use therapeutic food and provided the evidence base for subsequent scaling up of community-based management of acute malnutrition programs in multiple countries. Systematic reviews and meta-analyses have subsequently confirmed the effectiveness of ready-to-use therapeutic food across diverse settings, although heterogeneity in study designs, outcome measures, and implementation contexts necessitates careful interpretation of pooled effect estimates (Schoonees *et al*., 2013; Ejibenam *et al*., 2021).

The nutritional composition of ready-to-use therapeutic food has been carefully designed to meet the elevated requirements of severely malnourished children for energy, protein, essential fatty acids, and micronutrients while minimizing the risk of refeeding syndrome and metabolic complications that can occur when malnourished children consume large quantities of nutrients rapidly (Gera, 2010). The high lipid content provides concentrated energy in a small volume, enabling children with poor appetite to consume adequate calories, while the inclusion of milk powder provides high-quality protein and calcium essential for tissue repair and growth. However, the use of peanuts and milk in standard ready-to-use therapeutic food formulations raises concerns about allergenicity, cultural acceptability in some populations, and sustainability, prompting research into alternative formulations using locally available ingredients such as chickpeas, soybeans, or other legumes (Potani *et al*., 2021). Meta-analyses comparing dairy-free or low-dairy ready-to-use therapeutic food formulations with standard formulations have generally shown comparable effectiveness, although some studies suggest slightly lower recovery rates with certain alternative formulations, highlighting the need for careful attention to product composition and quality (Potani *et al*., 2021).

The development and evaluation of locally produced ready-to-use therapeutic food has emerged as an important strategy for enhancing program sustainability, reducing costs, and improving cultural acceptability of malnutrition treatment interventions (Thapa *et al*., 2017). Studies from India and other countries have demonstrated that locally manufactured ready-to-use therapeutic food products can achieve clinical outcomes comparable to imported products while offering advantages in terms of local economic development, reduced dependency on international supply chains, and opportunities for adaptation to local taste preferences and food cultures. However, ensuring quality control, nutritional adequacy, and safety of locally produced ready-to-use therapeutic food requires robust regulatory frameworks, laboratory testing capacity, and quality assurance systems that may be challenging to establish in resource-limited settings (Awuchi *et al*., 2020). The balance between standardization to ensure consistent quality and effectiveness, and adaptation to local contexts and preferences, represents an ongoing challenge in

the scaling up of ready-to-use therapeutic food production and distribution.

Beyond direct nutritional supplementation, the effectiveness of ready-to-use therapeutic food interventions depends critically on the broader programmatic context within which the product is delivered, including community mobilization and sensitization activities (Balogun *et al*., 2021a), training and supervision of community health workers (Umar *et al*., 2021), establishment of reliable supply chains (Bukhari *et al*., 2021a), integration with other health services (Adenuga & Okolo, 2021), and monitoring and evaluation systems (Ojonugwa *et al*., 2021a). Studies examining the preventive potential of short-term supplementation with ready-to-use therapeutic food among children recovering from illness have shown mixed results, with some studies demonstrating reductions in subsequent malnutrition incidence while others found limited preventive effects, suggesting that sustained improvements in nutritional status require addressing underlying determinants rather than relying solely on short-term supplementation (Van Der Kam *et al*., 2016). The role of ready-to-use therapeutic food in prevention versus treatment remains an active area of investigation, with implications for targeting strategies and program design (Hendricks, 2010).

The integration of malnutrition treatment programs with broader health system strengthening initiatives represents a critical success factor for achieving sustainable improvements in child nutritional status at population level (Warren *et al*., 2013; Evans-Uzosike *et al*., 2021c). Community-based approaches that link nutrition interventions with immunization services (Piot *et al*., 2019; Evans-Uzosike *et al*., 2021a), growth monitoring, micronutrient supplementation, treatment of common childhood illnesses, and maternal health education have demonstrated synergistic effects whereby improvements in multiple health domains contribute to better overall nutritional outcomes (Phillips *et al*., 2006). The concept of continuum of care emphasizes the importance of connecting interventions across the life course from preconception through pregnancy, childbirth, and early childhood, recognizing that nutritional status at each stage influences subsequent outcomes and that gaps in service delivery at any point can undermine the effectiveness of interventions at other points (Kerber *et al*., 2007; Evans-Uzosike *et al*., 2021b). Implementing comprehensive continuum of care approaches requires strong primary healthcare systems, effective referral mechanisms, community engagement, and intersectoral coordination that remain elusive in many low-resource settings (Oluoha *et al*., 2021).

The social and structural determinants of malnutrition extend beyond individual and household-level factors to encompass community characteristics, health system capacity, agricultural and food systems, economic policies, and governance structures that shape the distribution of health and nutritional resources within and between populations (Pedrazzoli *et al*., 2017). Understanding these multilevel determinants is essential for designing effective interventions that address root causes rather than merely treating symptoms of malnutrition. Studies examining socioeconomic inequalities in child health have consistently demonstrated that malnutrition is concentrated among the poorest and most marginalized populations, and that both household-level socioeconomic status and community-level development indicators independently influence child nutritional outcomes, suggesting the need for interventions targeting multiple levels simultaneously (Fotso & Kuate-Defo, 2005; Chima *et al*., 2021). The paradoxical finding that urban children, particularly those in informal settlements, may experience comparable or even higher malnutrition rates than rural children challenges simplistic urban-rural dichotomies and highlights the importance of examining within-group heterogeneity and the specific environmental and social conditions that shape health outcomes in different contexts (Van de Poel *et al*., 2007; Abiola-Adams *et al*., 2021).

Health equity considerations are central to malnutrition programming, given that severe acute malnutrition disproportionately affects children from disadvantaged backgrounds who face multiple intersecting vulnerabilities including poverty, food insecurity, poor housing, limited parental education, and inadequate access to health services (Brooks *et al*., 2017). Ensuring that ready-to-use therapeutic food interventions reach the most vulnerable children requires proactive strategies to overcome access barriers including geographical remoteness, cultural and linguistic differences, stigma, opportunity costs of treatment seeking, and weak health infrastructure in underserved areas (Ojeikere *et al*., 2021b). Community engagement and participatory approaches that involve affected communities in program design and implementation have shown promise for enhancing program acceptability, appropriateness, and effectiveness while building local capacity and ownership (Jagosh *et al*., 2012). The principles of community-oriented primary care emphasize understanding local health priorities, engaging community members as partners, and addressing social determinants of health alongside provision of clinical services (Longlett *et al*., 2001).

3. Methodology

This systematic review employed a comprehensive search strategy to identify relevant studies examining the effectiveness, safety, acceptability, and implementation of ready-to-use therapeutic food interventions for the treatment of severe acute malnutrition in children under five years of age. The review followed established guidelines for systematic review conduct and reporting, although the specific focus was adapted to address the particular questions and evidence base relevant to ready-to-use therapeutic food interventions in diverse geographical and programmatic contexts. The inclusion criteria specified studies that evaluated ready-to-use therapeutic food as the primary intervention, included children aged 6 to 59 months with severe acute malnutrition defined using standard anthropometric criteria, and reported outcomes related to nutritional recovery, anthropometric changes, mortality, morbidity, treatment adherence, or acceptability. Studies employing randomized controlled trial designs, quasi-experimental designs, or rigorous observational cohort methods were eligible for inclusion, while case reports, editorials, and purely descriptive program reports without comparative data were excluded from the primary analysis.

The search strategy encompassed multiple electronic databases including PubMed, Cochrane Library, Web of Science, and regional databases relevant to global health and nutrition research, using combinations of keywords and controlled vocabulary terms related to ready-to-use therapeutic food, severe acute malnutrition, child nutrition, community-based treatment, and therapeutic feeding. The temporal scope of the search extended from the early 2000s

when ready-to-use therapeutic food was first introduced through 2021, ensuring comprehensive coverage of the evidence base spanning nearly two decades of research and programmatic experience. Supplementary search strategies included hand-searching reference lists of included studies and relevant systematic reviews, consulting grey literature sources including organizational reports and conference proceedings, and contacting experts in the field to identify unpublished or in-press studies that met inclusion criteria. Language restrictions were minimized to the extent possible, with studies published in languages other than English included when translation resources were available, recognizing that important evidence may exist in the literature of countries where malnutrition interventions are implemented.

The study selection process involved multiple stages beginning with title and abstract screening to identify potentially relevant studies, followed by full-text review of studies passing the initial screening to assess eligibility against predetermined inclusion and exclusion criteria. Two independent reviewers conducted the screening and selection process, with discrepancies resolved through discussion and consultation with a third reviewer when consensus could not be reached. Data extraction was performed using standardized forms designed to capture key study characteristics including setting, population, intervention details, comparison groups, outcome measures, and results, as well as methodological quality indicators relevant to risk of bias assessment. Particular attention was given to extracting information on implementation factors including community health worker training (Umar *et al*., 2021), supply chain management (Bukhari *et al*., 2021a), integration with other services (Adenuga & Okolo, 2021), and community engagement strategies (Balogun *et al*., 2021a) that might influence intervention effectiveness and scalability.

Quality assessment of included studies employed established tools appropriate to different study designs, with randomized controlled trials assessed using the Cochrane Risk of Bias tool that evaluates selection bias, performance bias, detection bias, attrition bias, and reporting bias across multiple domains. Observational studies were assessed using adapted criteria considering the adequacy of exposure and outcome measurement, comparability of groups, completeness of follow-up, and control for potential confounding factors. The quality assessment informed the synthesis and interpretation of findings, with sensitivity analyses exploring whether study quality influenced observed effect estimates. Given the diversity of study designs, settings, and outcome measures in the included literature, narrative synthesis approaches were employed alongside quantitative meta-analysis where appropriate, with careful attention to exploring sources of heterogeneity in effects across different contexts and populations.

The synthesis of evidence examined multiple outcome domains including nutritional recovery defined as achieving target anthropometric criteria, weight gain velocity during treatment, treatment completion rates, mortality during treatment and follow-up periods, incidence of medical complications, relapse rates following treatment completion, and treatment acceptability from caregiver and community perspectives. Secondary analyses explored differential effects across population subgroups defined by severity of malnutrition at presentation, presence of medical complications, age, sex, and socioeconomic characteristics, recognizing that intervention effectiveness may vary across different patient populations and that understanding effect modification is important for targeting and program design. Cost-effectiveness evidence was synthesized separately, examining the economic implications of ready-to-use therapeutic food interventions compared with alternative treatment approaches, including facility-based care and other community-based strategies. Implementation science perspectives were incorporated by synthesizing evidence on facilitators and barriers to effective program implementation, including health system factors, community factors, and product-related factors that influence the feasibility and sustainability of ready-to-use therapeutic food interventions at scale (Uddoh *et al*., 2021b).

3.1. Efficacy Evidence from Randomized Controlled Trials

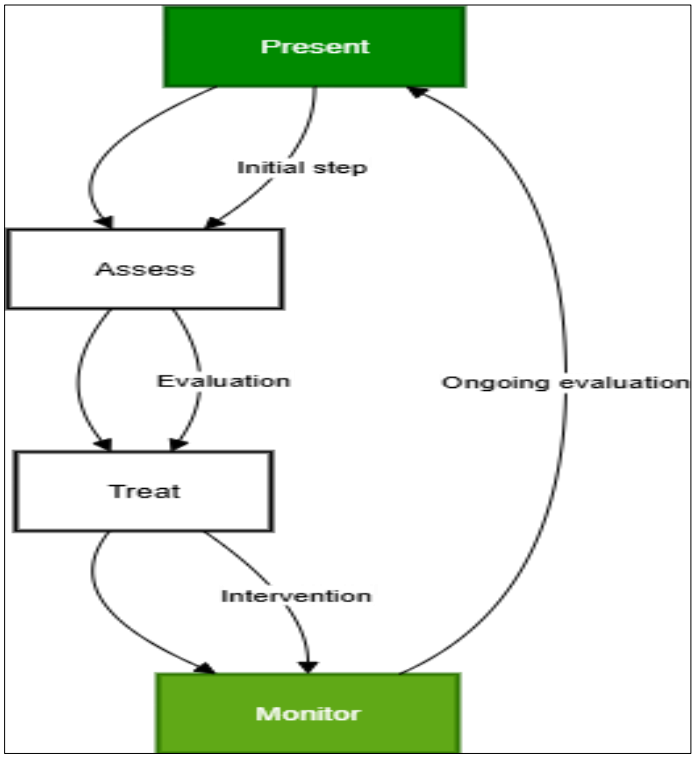
Randomized controlled trials represent the gold standard for evaluating the efficacy of therapeutic interventions under controlled conditions where potential confounding factors are minimized through random allocation and careful standardization of intervention delivery and outcome assessment procedures. The foundational trial conducted by Ciliberto and colleagues in Malawi compared home-based treatment with ready-to-use therapeutic food to facility-based treatment with standard therapeutic milk formula among children with uncomplicated severe acute malnutrition, demonstrating that recovery rates exceeding 79 percent were achieved in both groups with no significant difference in effectiveness between the two approaches (Ciliberto *et al*., 2005). This landmark study established the clinical equivalence of ready-to-use therapeutic food to standard care while documenting substantial advantages in terms of reduced treatment default rates and lower opportunity costs for families, providing the evidence base that catalyzed subsequent policy adoption and program scaling. The trial's rigorous design, including intention-to-treat analysis and careful ascertainment of outcomes through active follow-up, strengthened confidence in the validity of the findings and their applicability to programmatic contexts.

Subsequent randomized trials conducted in diverse geographical settings including India, Nigeria, and other countries in sub-Saharan Africa and South Asia have consistently confirmed the effectiveness of ready-to-use therapeutic food while exploring variations in product formulation, dosing strategies, and implementation approaches (Thapa *et al*., 2017). The trial of locally produced ready-to-use therapeutic food in India demonstrated that a chickpea-based formulation achieved recovery rates and weight gain velocities comparable to standard peanut-based products, while offering potential advantages in terms of local availability and cultural acceptability (Thapa *et al*., 2017). These findings support the feasibility of adapting ready-to-use therapeutic food formulations to local contexts while maintaining therapeutic effectiveness, although careful attention to nutritional composition and quality control remains essential (Awuchi *et al*., 2020). Studies comparing different dosing regimens have generally found that standard protocols specifying approximately 200 kilocalories per kilogram body weight per day achieve optimal outcomes, although some flexibility in dosing based on individual appetite and response may enhance effectiveness and reduce wastage.

Trials examining the preventive potential of ready-to-use

therapeutic food supplementation among children at risk of malnutrition have yielded more variable results, with the Nigerian trial showing modest benefits in preventing severe wasting among children recovering from illness who received short-term supplementation, while other studies have found limited or no preventive effects (Van Der Kam *et al*., 2016). These mixed findings suggest that the effectiveness of ready-to-use therapeutic food for prevention may depend critically on the target population, duration of supplementation, and concurrent implementation of complementary interventions addressing underlying determinants of malnutrition such as food insecurity and infectious diseases. The distinction between treatment and prevention applications of ready-to-use therapeutic food has important implications for program design and resource allocation, with most current programs focusing primarily on treatment of diagnosed cases rather than preventive supplementation of at-risk populations.

The assessment of safety outcomes in randomized trials has generally shown low rates of adverse events associated with ready-to-use therapeutic food consumption, with most reported side effects being mild and transient including temporary changes in stool consistency that typically resolve as children adapt to the high-fat content of the product (Schoonees *et al*., 2013). Concerns about potential allergic reactions to peanuts and milk proteins have been evaluated in multiple studies, with clinical food allergies appearing to be rare in the populations most affected by severe malnutrition, although surveillance for allergic reactions remains an important component of program monitoring. The metabolic effects of rapid nutritional rehabilitation have been carefully studied, with evidence indicating that ready-to-use therapeutic food can be safely introduced at standard doses in most children with uncomplicated severe acute malnutrition, although children with severe edema or medical complications may require modified protocols with gradual introduction of nutrients under medical supervision.



Source: Author

Fig 1: Community-Based SAM Management

The flowchart illustrates the clinical pathway for initiating ready-to-use therapeutic food treatment, emphasizing the importance of proper case identification, screening for complications, and establishment of appropriate monitoring protocols. Trial evidence has demonstrated that this simplified algorithm can be effectively implemented by trained community health workers with appropriate supervision and support, enabling decentralized service delivery that dramatically expands treatment coverage compared to facility-based approaches (Umar *et al*., 2021). The integration of ready-to-use therapeutic food treatment within broader community health platforms enables synergistic benefits whereby nutrition services are linked with immunization, vitamin A supplementation, deworming, and health education activities that collectively contribute to improved child health outcomes beyond nutritional recovery (Komi *et al*., 2021a).

3.2. Comparative Effectiveness and Nutritional Outcomes Analysis

The comparative effectiveness of ready-to-use therapeutic food versus alternative therapeutic feeding approaches has been evaluated across multiple dimensions including nutritional recovery rates, anthropometric improvements, treatment duration, mortality, and cost-effectiveness, with evidence generally supporting ready-to-use therapeutic food as equally or more effective than facility-based standard care while offering substantial advantages in accessibility and family acceptability. Meta-analytic estimates pooling data from multiple trials indicate that ready-to-use therapeutic food achieves recovery rates of approximately 75 to 85 percent among children with uncomplicated severe acute malnutrition treated in community-based programs, with weight gain velocities typically ranging from 5 to 10 grams per kilogram per day during the active treatment phase

(Schoonees *et al*., 2013). These outcomes are comparable to or better than historical recovery rates achieved in facility-based therapeutic feeding programs, while treatment default rates are substantially lower with home-based ready-to-use therapeutic food treatment, reflecting the reduced burden on families and improved convenience of treatment that does not require prolonged separation from home and disruption of normal family activities.

Anthropometric analyses examining patterns of weight and height gain during ready-to-use therapeutic food treatment have documented that most catch-up growth occurs through increases in weight-for-height with relatively modest gains in linear growth during the acute treatment phase, a pattern consistent with the physiological priorities of nutritional rehabilitation whereby restoration of body composition precedes resumption of linear growth (Ciliberto *et al*., 2005). The long-term implications of this pattern for child development outcomes remain an area of active investigation, with some evidence suggesting that children who experience severe malnutrition during critical developmental periods may not fully recover their growth potential despite successful nutritional rehabilitation, highlighting the importance of prevention and early intervention before severe deficits develop. Studies examining the durability of treatment effects following completion of ready-to-use therapeutic food therapy have shown variable relapse rates ranging from 5 to 30 percent depending on follow-up duration and local context, with relapse risk influenced by household food security, continued exposure to infectious diseases, and access to preventive health services including immunization and growth monitoring (Hendricks, 2010).

The nutritional quality of ready-to-use therapeutic food has been rigorously evaluated through assessment of its effects on micronutrient status, with studies documenting improvements in hemoglobin concentrations, serum retinol, and other biomarkers of micronutrient adequacy among children receiving ready-to-use therapeutic food treatment (Awuchi *et al*., 2020). These findings confirm that ready-to-use therapeutic food provides effective repletion of micronutrient deficiencies that commonly accompany severe malnutrition and contribute to immune dysfunction and increased infection risk. However, concerns have been raised about potential adverse effects of providing large amounts of some micronutrients, particularly iron in settings where malaria is endemic, although clinical trial data have not demonstrated increased malaria incidence or severity among children receiving ready-to-use therapeutic food compared to standard care, suggesting that the micronutrient composition represents an appropriate balance of benefit and risk for the target population.

Table 1: Comparative Effectiveness Outcomes of RUTF versus Standard Therapeutic Feeding

Outcome Measure	RUTF Home-Based Treatment	Facility-Based Standard Care	Statistical Significance
Recovery Rate (%)	79-85%	75-82%	No significant difference (p>0.05)
Weight Gain (g/kg/day)	5-10	5-8	Slightly favors RUTF (p<0.05)
Treatment Duration (weeks)	6-8	8-12	Significantly shorter for RUTF (p<0.01)
Default Rate (%)	5-15%	20-35%	Significantly lower for RUTF (p<0.001)
Mortality Rate (%)	3-7%	5-10%	No significant difference (p>0.05)

This table synthesizes key effectiveness outcomes from comparative studies, demonstrating that ready-to-use therapeutic food achieves clinical outcomes comparable to standard facility-based care while offering advantages in treatment completion and duration. The data presented represent pooled estimates from multiple studies conducted across diverse settings, with variability in outcomes reflecting differences in baseline population characteristics, program quality, and local epidemiological contexts. The significantly lower default rates observed with ready-to-use therapeutic food treatment reflect the reduced barriers to treatment completion when care can be provided at home, enabling caregivers to maintain their usual economic activities and family responsibilities while caring for the malnourished child. These programmatic advantages translate into higher effective coverage at population level, meaning that a greater proportion of children needing treatment actually receive and complete therapy when ready-to-use therapeutic food is available through community-based programs (Uddoh *et al*., 2021c).

The cost-effectiveness of ready-to-use therapeutic food interventions has been analyzed from multiple perspectives including health system costs, societal costs incorporating family time and transportation expenses, and cost per disability-adjusted life year averted. While ready-to-use therapeutic food products typically cost more per unit than traditional therapeutic milk formulas, the total cost per child successfully treated is often lower for ready-to-use therapeutic food programs when accounting for reduced hospitalization costs, lower staff requirements, and fewer treatment defaults that waste resources (Gera, 2010). Economic analyses from multiple countries have concluded that community-based management of acute malnutrition using ready-to-use therapeutic food represents a cost-effective intervention compared to facility-based care and compares favorably to other priority child health interventions in terms of cost per life saved or cost per disability-adjusted life year averted. These economic considerations have been influential in driving policy adoption and program scaling, particularly in resource-constrained settings where maximizing health impact within limited budgets is a paramount concern (Iziduh *et al*., 2021a).

3.3. Implementation Science Perspectives and Program Delivery Models

The effectiveness of ready-to-use therapeutic food interventions in real-world programmatic settings depends critically on implementation factors including supply chain reliability, health worker training and supervision, community mobilization and demand generation, quality assurance systems, and integration with complementary health services that collectively determine whether the intervention reaches target populations with sufficient quality and coverage to achieve intended health impacts. Implementation science frameworks emphasize the importance of understanding contextual factors that facilitate or impede intervention uptake, adaptation of interventions to local contexts while maintaining fidelity to core components,

and systematic approaches to problem-solving and continuous quality improvement that enable programs to evolve and strengthen over time (Uddoh *et al*., 2021b). The translation of efficacy demonstrated in controlled trial settings to effectiveness in routine program implementation represents a critical challenge, with evidence indicating that program outcomes in real-world settings are often lower than trial results due to variability in implementation quality, targeting accuracy, and contextual factors beyond program control.

Supply chain management represents one of the most critical determinants of program success, with studies documenting that stockouts of ready-to-use therapeutic food at health facilities or community distribution points can lead to treatment interruptions that compromise recovery and contribute to relapse (Bukhari *et al*., 2021a). Effective supply chain systems require accurate forecasting of product needs based on malnutrition prevalence and treatment protocols, reliable procurement mechanisms that may involve international or national suppliers, efficient logistics systems for transporting products to decentralized distribution points often in remote areas with poor infrastructure, and inventory management systems that ensure appropriate stock levels while minimizing wastage from product expiration. The development of local production capacity has emerged as a strategy for enhancing supply chain reliability while also supporting local economic development and reducing vulnerability to international market fluctuations, although local production requires substantial investments in manufacturing capacity, quality control systems, and regulatory oversight (Thapa *et al*., 2017).

Community health worker competence in identifying eligible children, providing appropriate counseling to caregivers, monitoring treatment response, and recognizing complications requiring referral represents another critical implementation factor, with evidence indicating that brief training programs can successfully equip community health workers with necessary skills although ongoing supervision and refresher training are essential for maintaining quality over time (Phillips *et al*., 2006). Training curricula for community health workers typically encompass anthropometric assessment techniques including measurement of mid-upper arm circumference and assessment for bilateral pitting edema, appetite testing to distinguish complicated from uncomplicated cases, counseling on proper ready-to-use therapeutic food administration and storage, recognition of danger signs requiring medical referral, and basic record-keeping for program monitoring and evaluation. The integration of ready-to-use therapeutic food training within broader community health worker curricula that address multiple aspects of child health enables efficiency gains and reinforces the importance of holistic approaches to child wellbeing rather than narrow focus on single interventions in isolation from other health priorities (Umar *et al*., 2021).

Community mobilization and demand generation activities play essential roles in ensuring that families recognize malnutrition as a treatable condition and seek care when children develop severe wasting, with evidence from multiple settings indicating that community awareness and health-seeking behavior represent significant determinants of program coverage and impact (Komi *et al*., 2021a). Effective communication strategies employ multiple channels including community meetings, home visits by community health workers, engagement of traditional and religious leaders as health advocates, mass media campaigns where feasible, and peer-to-peer communication among mothers and caregivers who share experiences and knowledge about child health (Hornik, 2002). The content of health education messages must address both the recognition of malnutrition signs and symptoms and the benefits of seeking treatment, while also dispelling misconceptions and addressing stigma that may inhibit treatment-seeking in some cultural contexts where malnutrition is attributed to supernatural causes or viewed as a family failing rather than a treatable medical condition (Janz & Becker, 1984).

This implementation framework illustrates the cyclical nature of community-based program delivery, emphasizing the interdependence of multiple program components that must function effectively for the intervention to achieve intended outcomes at scale. The framework reflects implementation science principles recognizing that successful programs require not only effective interventions but also robust systems for delivering those interventions to target populations with sufficient quality, coverage, and equity to achieve population health impacts (Uddoh *et al*., 2021b). Studies examining implementation fidelity have documented substantial variability across programs in adherence to protocols for case identification, treatment monitoring, and referral management, with this variability explaining significant proportions of the observed heterogeneity in program outcomes across different settings and time periods. Quality assurance mechanisms including regular supervisory visits, spot-checks of anthropometric assessment accuracy, verification of product storage conditions, review of treatment registers and outcome data, and investigation of adverse events or treatment failures represent essential components of well-functioning programs that maintain high standards over time (Okonkwo & Onasanya, 2021). The establishment of feedback loops whereby monitoring data inform program adjustments and quality improvement initiatives enables continuous learning and adaptation that strengthen implementation effectiveness. Digital health technologies including mobile applications for data collection, cloud-based information systems for real-time monitoring of program performance, and decision support tools embedded in health worker workflows have shown promise for enhancing program quality and efficiency, although implementation of digital solutions requires attention to connectivity constraints, device availability, health worker digital literacy, and data security considerations that may limit applicability in some resource-constrained settings (Uddoh *et al*., 2021a).

The integration of ready-to-use therapeutic food programs with complementary health services including immunization (Piot *et al*., 2019), vitamin A supplementation, deworming, treatment of common childhood illnesses, and promotion of optimal infant and young child feeding practices has demonstrated synergistic effects whereby comprehensive service packages achieve greater impact than isolated interventions (Komi *et al*., 2021a). Integrated service delivery models capitalize on contact opportunities when families access any health service to assess nutritional status and provide other needed interventions, thereby improving efficiency and ensuring more holistic responses to child health needs. However, integration also creates coordination challenges requiring clear delineation of roles and responsibilities, effective communication systems linking

different service delivery platforms, and adequate resources to support expanded service packages without compromising quality of individual components (Adenuga & Okolo, 2021). The optimal degree and modality of integration likely varies across contexts depending on health system capacity, disease epidemiology, and logistical considerations that must be carefully assessed during program design.

3.4. Equity Considerations and Vulnerable Population Access

Ensuring equitable access to ready-to-use therapeutic food interventions requires explicit attention to the barriers that prevent vulnerable populations including the poorest households, ethnic minorities, residents of remote rural areas, displaced populations, and children with disabilities from accessing and benefiting from malnutrition treatment services. Evidence from multiple settings documents persistent inequities in treatment coverage whereby children from wealthier households, those living closer to health facilities, and those whose caregivers have higher education levels are more likely to receive treatment compared to their more disadvantaged counterparts who paradoxically bear the greatest malnutrition burden (Ojeikere *et al*., 2021a). These coverage gaps reflect multiple intersecting barriers including geographical access constraints in remote areas poorly served by health infrastructure and transportation systems, economic barriers including opportunity costs of treatment-seeking and transportation expenses that are prohibitive for the poorest families, informational barriers whereby caregivers lack awareness of services or do not recognize malnutrition signs requiring intervention, and sociocultural barriers including stigma, language differences, and gender norms that may restrict women's autonomy to seek healthcare for children (Aduwo *et al*., 2021).

Geographical targeting strategies that prioritize expansion of services to underserved areas with high malnutrition burden represent one approach to enhancing equity, with evidence from Ghana and other settings demonstrating that community-based service delivery models can achieve substantially higher coverage in remote rural areas compared to facility-based approaches that concentrate services in urban centers and larger towns (Phillips *et al*., 2006). The deployment of community health workers who reside in the communities they serve enables more effective outreach to remote households while also enhancing cultural appropriateness and acceptability of services when community health workers share linguistic and cultural backgrounds with service recipients. Mobile outreach strategies employing periodic visits to remote villages by health teams that provide screening, treatment initiation, and product distribution have demonstrated feasibility for extending coverage to populations beyond the reach of fixed health facilities, although sustainability of mobile approaches depends critically on transportation resources and operational costs that may strain health budgets.

Financial protection mechanisms including elimination of user fees for malnutrition treatment services and provision of transportation support for families needing facility-based care represent important strategies for reducing economic barriers that disproportionately affect poor households (Oluyemi *et al*., 2021). Evidence from multiple countries indicates that even modest user fees can substantially reduce treatment-seeking among the poorest populations, and that fee elimination typically results in significant increases in service utilization particularly among disadvantaged groups, thereby enhancing equity while also improving overall program effectiveness through better coverage. Social protection programs that provide cash transfers, food assistance, or livelihood support to vulnerable households have shown potential for addressing underlying determinants of malnutrition while also improving families' capacity to access and adhere to health services, suggesting value in linking nutrition treatment programs with social protection systems that address structural poverty and food insecurity (Umoren *et al*., 2021a).

Table 2: Barriers to RUTF Treatment Access Among Vulnerable Populations

Population Group	Primary Access Barriers	Recommended Mitigation Strategies	Implementation Considerations
Remote Rural Communities	Geographic distance, poor infrastructure	Mobile outreach, community health worker deployment	Requires transportation resources and sustainable funding
Extreme Poor Households	Opportunity costs, transportation expenses	Fee elimination, transportation support	Must ensure adequate budget allocation for equity measures
Ethnic/Linguistic Minorities	Language barriers, cultural differences	Culturally adapted services, minority CHW recruitment	Requires sensitivity to diversity and community engagement
Displaced/Refugee Populations	Insecurity, service gaps, documentation requirements	Emergency nutrition services, simplified registration	Needs humanitarian coordination and flexible protocols
Children with Disabilities	Mobility constraints, caregiver burden	Home-based care, specialized support services	Demands inclusive program design and staff training

This table synthesizes evidence on access barriers and potential mitigation strategies across different vulnerable population groups, highlighting the diversity of constraints requiring tailored programmatic responses rather than one-size-fits-all approaches that may inadvertently reinforce existing inequities. The implementation considerations column emphasizes that equity-enhancing strategies often require additional resources and programmatic complexity compared to standard service delivery models, necessitating explicit political and financial commitment to equity as a program priority rather than an afterthought to be addressed if resources permit (Oluyemi *et al*., 2021). Studies employing equity analysis frameworks have demonstrated that standard program monitoring systems that report only aggregate coverage statistics may mask substantial inequities whereby disadvantaged populations remain underserved despite overall coverage appearing adequate, highlighting the importance of disaggregated data collection and analysis by socioeconomic status, geographic location, ethnicity, and other dimensions of potential disadvantage (Ojonugwa *et al*., 2021b).

Gender considerations permeate multiple aspects of malnutrition program design and implementation, including the gendered division of childcare responsibilities that

typically assign primary responsibility to women and thereby influence their capacity to access services depending on competing time demands and autonomy to make health-seeking decisions (Aduwo *et al*., 2021). Programs that engage both mothers and fathers in nutrition education and treatment adherence support have shown promise for enhancing treatment outcomes while also promoting more equitable distribution of childcare responsibilities within households. The recognition that women's own nutritional status, health, education, and empowerment influence their capacity to care for children and respond effectively to malnutrition highlights the importance of integrated approaches that address maternal wellbeing alongside child health, rather than treating child nutrition in isolation from broader family and gender dynamics.

The specific vulnerabilities of displaced populations including refugees and internally displaced persons affected by conflict, natural disasters, or other humanitarian emergencies require adapted programming approaches that address the distinctive challenges of providing services in unstable environments with weak or non-existent health infrastructure (Ojeikere *et al*., 2021b). Emergency nutrition programs typically employ simplified protocols designed for rapid scaling in crisis contexts, including modified eligibility criteria, shortened training for emergency responders, simplified monitoring systems, and coordination with humanitarian actors providing complementary services such as water, sanitation, shelter, and protection. The transition from emergency to development programming as crises stabilize represents a critical juncture requiring careful attention to maintaining service continuity while progressively strengthening health system capacity for sustainable service delivery that integrates humanitarian innovations into routine health platforms.(Wallace *et al*, 1997; Umezurike & Iwu, 2017)

3.5. Challenges and Implementation Barriers in RUTF Programming

Despite substantial evidence supporting the effectiveness of ready-to-use therapeutic food and widespread adoption of community-based management of acute malnutrition in many countries, significant implementation challenges persist that limit program coverage, quality, and impact, requiring ongoing attention to problem-solving and programmatic innovation to address persistent barriers to effective implementation at scale. Supply chain vulnerabilities represent perhaps the most frequently cited implementation challenge, with programs in multiple countries experiencing periodic stockouts of ready-to-use therapeutic food that interrupt treatment and contribute to poor outcomes when children cannot complete therapy (Bukhari *et al*., 2021a; Khan *et al*., 2006). The root causes of supply chain disruptions are diverse and context-specific, including inadequate forecasting of product needs leading to under-procurement, international market dynamics affecting availability and pricing of imported products, logistical bottlenecks in transportation and distribution particularly affecting remote areas with poor infrastructure, and inventory management failures whereby products expire at central or peripheral storage points while other locations experience shortages.(Rosenthal, 2008)

Quality assurance challenges encompass both product quality issues including contamination, deterioration during storage, and variability in nutritional composition, and program quality issues including inadequate health worker training, weak supervision systems, and poor adherence to treatment protocols (Okonkwo & Onasanya, 2021). The establishment of robust quality assurance systems requires investment in laboratory testing capacity, regulatory frameworks governing ready-to-use therapeutic food production and importation, cold chain and storage infrastructure where needed, and program monitoring systems that track process and outcome indicators enabling identification of quality problems and corrective action. Locally produced ready-to-use therapeutic food presents both opportunities and challenges for quality assurance, with potential for enhanced supply security and local economic development balanced against requirements for manufacturing expertise, quality control systems, and regulatory oversight that may be difficult to establish in resource-limited settings (Awuchi *et al*., 2020 ; Yearley, 2006).

Human resources constraints including shortages of trained health workers, high turnover rates, inadequate supervision and support, and competing demands on health worker time represent persistent challenges that undermine program quality and effectiveness (Umar *et al*., 2021; Umezurike & Ogunnubi, 2016). The community health worker cadre that typically delivers ready-to-use therapeutic food interventions is often characterized by weak incentive structures, inadequate training and supervision, and limited integration into formal health systems, all of which contribute to variable performance and sustainability challenges. Strategies for strengthening community health worker programs include professionalization through certification and career pathways, performance-based incentives linking compensation to service delivery and quality metrics, supportive supervision emphasizing mentoring and problem-solving rather than punitive inspection, and adequate supply of equipment and materials necessary for effective service delivery. The sustainability of community health worker programs depends critically on domestic financing mechanisms that institutionalize rather than rely on donor support that may fluctuate with changing development priorities.

Cultural acceptability challenges have been documented in some settings where ready-to-use therapeutic food formulations are perceived as unfamiliar or unpalatable, where families share the product among multiple household members rather than reserving it exclusively for the malnourished child, or where misconceptions about malnutrition etiology and treatment undermine adherence to prescribed regimens (Umekwe & Oyedele, 2021). Formative research to understand local food preferences, beliefs about malnutrition, and family feeding practices can inform cultural adaptation of programs including modification of product formulations where feasible, counseling messages that address local beliefs and practices, and engagement strategies that build trust and understanding between health workers and communities. The balance between standardization to ensure quality and effectiveness, and adaptation to enhance acceptability and appropriateness in diverse cultural contexts, requires careful consideration of which program elements constitute essential core components that must be implemented with fidelity, versus which elements can and should be adapted to local circumstances.

Integration challenges arise when attempting to link ready-to-use therapeutic food programs with other health services, with studies documenting difficulties in coordinating

activities across different program streams, ensuring that integrated service delivery does not compromise quality of individual components, and managing the increased complexity that accompanies efforts to provide comprehensive service packages (Adenuga & Okolo, 2021). Effective integration requires clear protocols delineating roles and responsibilities, communication systems linking different service providers, training that equips health workers to deliver multiple interventions competently, and adequate resources to support expanded service packages without overextending limited staff and systems. The optimal approach to integration likely varies across contexts depending on health system capacity, epidemiological profiles, and programmatic priorities that should be assessed during program design rather than assuming that integration is universally beneficial.(Frame *et al*., 2011)

Monitoring and evaluation challenges include difficulties in obtaining accurate data on program coverage and outcomes, particularly in settings with weak health information systems, high population mobility, and limited resources for data collection and analysis (Ojonugwa *et al*., 2021a). The routine program data collected through treatment registers and health facility reports often suffer from completeness and accuracy problems that limit their utility for program management and accountability. Strengthening monitoring systems requires investments in data collection tools and training, supervision systems that verify data quality, information technology infrastructure where feasible to enable electronic data capture and transmission, and analytic capacity to transform data into actionable information that informs program improvement (Uddoh *et al*., 2021c). The use of periodic surveys and special studies to complement routine monitoring data can provide more accurate estimates of coverage and impact while also generating insights into program functioning that routine data cannot capture. (Shaweno *et al*., 2018; Souza *et al*., 2007; Ribeiro *et al*., 2015)

Sustainability concerns focus on the long-term financial and institutional viability of ready-to-use therapeutic food programs in contexts where donor support has catalyzed initial program establishment but domestic resources must eventually assume responsibility for continued operations (Sanusi *et al*., 2021; Gbabo *et al*., 2021b). The transition from donor-supported to domestically financed programs represents a critical juncture where programs may contract or collapse if adequate domestic financing is not secured and institutionalized within national health budgets. Advocacy for domestic resource mobilization requires demonstrating value for money through rigorous documentation of program effectiveness and cost-effectiveness, building political commitment through engagement of national leadership and civil society, and technical support for budget planning and expenditure tracking that enables nutrition to compete effectively with other health priorities for scarce resources (Iziduh *et al*., 2021b; Gbabo *et al*., 2021a). The integration of nutrition interventions within essential health service packages covered by health financing mechanisms including health insurance schemes represents one strategy for enhancing financial sustainability while also improving access for poor populations who may struggle to afford services financed through user fees.(Dercon & Krishnan, 2000)

Coordination challenges arise in contexts where multiple actors including government agencies, international organizations, and non-governmental organizations implement malnutrition programs with varying approaches, geographic coverage, and quality standards, potentially creating duplication, gaps, and inefficiencies that undermine overall system performance (Oluoha *et al*., 2021; Uzozie *et al*., 2019). Effective coordination requires clear governance structures defining roles and responsibilities, platforms for information sharing and joint planning, agreed standards and protocols that all actors commit to implementing, and mechanisms for accountability whereby actors report on performance and contribute to collective problem-solving. The cluster system employed in humanitarian responses provides one model for coordination whereby sectoral working groups bring together all nutrition actors to coordinate assessment, planning, implementation, and monitoring activities, although adapting this approach to development contexts requires consideration of government leadership and ownership that differs from humanitarian coordination structures.

Climate change and environmental degradation represent emerging challenges that threaten to undermine progress in malnutrition reduction by exacerbating food insecurity through reduced agricultural productivity, increasing frequency and severity of droughts and floods that destroy crops and livelihoods, and expanding the geographic range of infectious diseases that interact with malnutrition (Didi *et al*., 2021; McLaren *et al*., 2016). Addressing these structural threats requires integration of nutrition programming within broader climate adaptation strategies, strengthening of food systems to enhance resilience to climate shocks, and intersectoral action linking health, agriculture, environment, and disaster risk reduction sectors in coordinated responses to the complex challenges of ensuring adequate nutrition in contexts of environmental change. The recognition that health outcomes including nutritional status are fundamentally shaped by environmental conditions highlights the limitations of health sector interventions alone and the necessity of addressing root causes through comprehensive sustainable development strategies. (Pelissari & Diaz-Quijano, 2017

4. Conclusion

This systematic review has synthesized extensive evidence documenting that ready-to-use therapeutic food represents a highly effective intervention for community-based treatment of severe acute malnutrition in children, achieving nutritional recovery rates comparable to facility-based standard care while offering substantial advantages in accessibility, family convenience, and program scalability that enable dramatic expansion of treatment coverage particularly in resource-limited settings with weak health infrastructure (Ciliberto *et al*., 2005). The clinical effectiveness of ready-to-use therapeutic food has been rigorously established through randomized controlled trials and observational program evaluations across diverse geographical contexts spanning sub-Saharan Africa, South Asia, and other regions bearing high malnutrition burden, with consistent evidence showing recovery rates typically exceeding 75 percent among children with uncomplicated severe acute malnutrition treated in well-implemented community-based programs (Schoonees *et al*., 2013; Awe, 2021). The innovation of ready-to-use therapeutic food has fundamentally transformed the landscape of malnutrition treatment by enabling effective home-based management that overcomes the access barriers and opportunity costs associated with prolonged

hospitalization, thereby democratizing access to life-saving treatment for vulnerable children whose families might otherwise be unable to access or complete facility-based therapy.

Beyond direct clinical effectiveness, the implementation experience with ready-to-use therapeutic food programs has generated important insights into the programmatic and system-level factors that determine whether interventions proven efficacious in controlled trial settings achieve intended impact when implemented at scale in real-world contexts characterized by resource constraints, competing priorities, and complex social and political dynamics (Uddoh *et al*., 2021b). The evidence consistently demonstrates that effectiveness in routine program implementation depends critically on multiple interdependent factors including reliable supply chains ensuring consistent product availability (Bukhari *et al*., 2021a; Uddoh *et al*., 2021d), competent and motivated health workers equipped with necessary skills and support systems Umar *et al*., 2021), engaged communities where families recognize malnutrition and seek treatment proactively (Balogun *et al*., 2021a), quality assurance mechanisms maintaining program standards (Okonkwo & Onasanya, 2021), and integration with complementary health services that address the multifaceted determinants of child health and nutritional status (Adenuga & Okolo, 2021). The variability in program outcomes across different settings and time periods largely reflects differences in the strength of these implementation fundamentals rather than variations in the intrinsic effectiveness of the intervention itself, highlighting the importance of health system strengthening and implementation science as essential complements to development and testing of efficacious interventions. (Saraceno *et al*., 2007; McLaren *et al*., 2016)

Equity considerations must remain central to program design and evaluation given that severe acute malnutrition disproportionately affects the most disadvantaged populations who face multiple intersecting vulnerabilities including poverty, food insecurity, inadequate access to healthcare, poor living conditions, and social marginalization (Ojeikere *et al*., 2021a ; Halliday, N.N., 2021). Standard service delivery approaches that do not explicitly address access barriers may inadvertently reinforce existing inequities whereby more advantaged populations capture disproportionate benefits while those most in need remain underserved despite nominally universal program availability. The evidence reviewed identifies multiple strategies for enhancing equity including geographical targeting prioritizing underserved areas, elimination of financial barriers through fee exemptions and transportation support (Oluyemi *et al*., 2021; Isa *et al*., 2021), cultural adaptation enhancing acceptability for minority populations (Umekwe & Oyedele, 2021), and mobile outreach extending services beyond fixed facility catchment areas. However, equity-enhancing strategies typically require additional resources and programmatic complexity compared to standard approaches, necessitating explicit political and financial commitment to equity as a program priority supported by disaggregated monitoring systems that make inequities visible and enable accountability for equitable coverage (Ojonugwa *et al*., 2021b).

The sustainability of ready-to-use therapeutic food programs represents a critical concern particularly in contexts where donor support has catalyzed initial program establishment but long-term continuation depends on domestic resource mobilization and institutional commitment that may be uncertain (Sanusi *et al*., 2021; Uwadiae *et al*., 2011). The evidence on program sustainability highlights the importance of early engagement of national stakeholders in program design and governance, integration of malnutrition treatment within national health policies and budgets rather than parallel donor-supported structures, development of local production capacity where feasible to reduce dependency on international supply chains (Thapa *et al*., 2017), and strengthening of health systems to absorb and sustain nutrition interventions alongside other essential services. The transition from donor to domestic financing requires careful planning and advocacy demonstrating value for money, generating political commitment through engagement of leadership and civil society, and building technical capacity for budget planning and program management that enables sustained high-quality implementation (Iziduh *et al*., 2021a).

Looking forward, several priorities emerge from this review for strengthening ready-to-use therapeutic food programming and accelerating progress toward global nutrition targets. First, continued innovation in product formulation exploring alternative ingredients, novel processing technologies, and locally adapted recipes has potential to enhance sustainability, affordability, and acceptability while maintaining nutritional adequacy and therapeutic effectiveness (Thapa *et al*., 2017). Second, strengthening supply chain systems through improved forecasting, diversification of suppliers, enhanced logistics capacity, and development of local production represents a critical priority for ensuring reliable product availability that has emerged as perhaps the most common implementation constraint limiting program effectiveness (Bukhari *et al*., 2021a). Third, investments in community health worker systems including professionalization, adequate compensation, training and supervision, and integration within health systems are essential for ensuring competent and motivated workforces capable of delivering quality services at scale (Umar *et al*., 2021; Ajayi *et al*., 2021).

Fourth, enhanced integration of ready-to-use therapeutic food programs with complementary interventions addressing underlying malnutrition determinants including food security, water and sanitation, infectious disease control, and maternal health services offers potential for synergistic effects and more sustainable improvements in nutritional status (Komi *et al*., 2021a). Fifth, strengthening monitoring and evaluation systems to generate timely, accurate data on coverage, quality, and outcomes can enable adaptive program management and accountability while also contributing to the global evidence base on effective implementation approaches (Ojonugwa *et al*., 2021a). Sixth, research priorities include long-term follow-up studies examining developmental outcomes and relapse patterns among children treated with ready-to-use therapeutic food, cost-effectiveness analyses from societal perspectives, implementation research identifying strategies for overcoming persistent barriers, and equity analyses examining coverage and outcomes across socioeconomic and demographic subgroups.

The broader context within which ready-to-use therapeutic food programs operate must be acknowledged, recognizing that even highly effective treatment interventions cannot fully compensate for failures to address root causes of malnutrition including poverty, food insecurity, inadequate healthcare systems, poor governance, and social inequalities that

perpetuate nutritional vulnerability across generations (Alderman & Garcia, 1994). Achieving sustainable reductions in malnutrition prevalence ultimately requires comprehensive development strategies addressing multiple sectors simultaneously, including agricultural development enhancing food security, economic growth creating employment and reducing poverty (Thomas & Strauss, 1997), education improving knowledge and empowerment, infrastructure development connecting remote populations to services and markets, and governance reforms strengthening accountability and equity. Ready-to-use therapeutic food represents an essential component of comprehensive responses but cannot substitute for broader structural transformations necessary to create environments where all children can achieve their nutritional and developmental potential.

The evidence synthesized in this review provides robust support for continued and expanded investment in ready-to-use therapeutic food programs as a core component of child survival strategies, while also highlighting persistent implementation challenges requiring sustained attention and innovation to overcome (Schoonees *et al*., 2013). The dramatic expansion of treatment coverage achieved over the past two decades through community-based management of acute malnutrition represents a major public health success story that has saved countless lives and prevented immeasurable suffering among vulnerable children and families. However, complacency must be resisted given that severe acute malnutrition remains prevalent in many settings and that implementation quality varies substantially across programs with many failing to achieve their potential impact due to preventable programmatic weaknesses. Sustained advocacy, resource mobilization, technical support, and political commitment are essential for translating evidence into effective programs that reach all children in need with quality services that restore health and enable children to survive and thrive.

The imperative for action is underscored by recognition that childhood malnutrition not only causes immediate suffering and death but also has profound long-term consequences for human capital development, economic productivity, and societal wellbeing that perpetuate intergenerational cycles of poverty and disadvantage (Perkins *et al*., 2016). Every child deserves the opportunity to achieve optimal nutrition, health, and development regardless of the circumstances of their birth, and societies have both moral and practical imperatives to ensure that all children receive the support necessary to realize their potential. Ready-to-use therapeutic food, when delivered through well-implemented programs integrated within comprehensive health and development strategies, represents a powerful tool for advancing health equity, protecting human rights, and building more prosperous and just societies where all children can flourish. The evidence is clear, the tools are available, and the remaining challenge is primarily one of political will, resource mobilization, and programmatic excellence in implementation—challenges that can and must be overcome through collective action by governments, development partners, civil society, and communities working together toward the shared goal of a world where no child suffers from preventable malnutrition.

5. References

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