

A SURVEY ON THE ROLE OF SCHOOL FEEDING AND RUTF-BASED INTERVENTIONS IN COMBATING CHILD MALNUTRITION IN PAKISTAN

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Abstract

Background: Child malnutrition remains one of Pakistan's most persistent public health and development challenges. According to the National Nutrition Survey 2018, 40.2% of children under five are stunted, 17.7% are wasted, and 28.9% are underweight, while more than half suffer from micronutrient deficiencies such as anaemia.

Objectives: This survey synthesises evidence published between 2020 and 2025 on two complementary interventions – school feeding programmes and Ready-to-Use Therapeutic Food (RUTF) – assessing their effectiveness, their implementation challenges, and the potential of data-driven approaches to strengthen delivery in Pakistan.

Methodology: A qualitative systematic literature review guided by PRISMA 2020 reporting principles was adopted. PubMed, Scopus, and Google Scholar, together with the institutional repositories of WFP, UNICEF, WHO, the World Bank, and the Government of Pakistan, were searched. Eleven core sources satisfying predefined inclusion criteria were retained, appraised for quality, and analysed through thematic coding.

Findings: School feeding improves dietary diversity, micronutrient sufficiency, attendance (increases approaching 20%), retention, and cognitive performance. RUTF achieves recovery rates of 75–90% among children with severe acute malnutrition. However, donor-dependent financing, reliance on imported RUTF, supply-chain fragility, infrastructural gaps, and weak monitoring systems constrain scale and sustainability.

Conclusion: An integrated continuum of preventive school feeding and curative RUTF-based care – supported by local RUTF production, digital monitoring, community engagement, and institutionalised policy financing – offers the most viable pathway for reducing child malnutrition in Pakistan.

1. Introduction

1.1 Background of the Study

Child malnutrition is among the most serious threats to human capital formation in Pakistan. Globally, an estimated 148 million children under five are stunted and 45 million are wasted (UNICEF, WHO, & World Bank, 2023), and South Asia carries a disproportionate share of

this burden. Within the region, Pakistan's indicators are particularly alarming: the National Nutrition Survey 2018 reports that 40.2% of children under five are stunted, 17.7% are wasted, and 28.9% are underweight, while more than half are anaemic (Government of Pakistan & UNICEF, 2019). Beyond its immediate health toll, malnutrition is estimated

to cost Pakistan approximately 3% of GDP every year through lost productivity, healthcare expenditure, and diminished educational attainment (World Bank, 2022). The catastrophic 2022 floods, which affected an estimated 33 million people, further deepened food insecurity and pushed acute malnutrition in parts of Sindh and Balochistan to emergency levels, underscoring the urgency of effective, scalable nutrition interventions.

Two interventions dominate the policy and programmatic response. School feeding programmes act preventively, providing regular meals or fortified snacks to school-age children in order to improve nutrition while simultaneously strengthening enrolment, attendance, and learning (WFP, 2022). Ready-to-Use Therapeutic Food acts curatively: it is the internationally recommended treatment for severe acute malnutrition (SAM), delivered largely through community-based management of acute malnutrition (CMAM) programmes (WHO, 2023). This paper surveys the recent evidence on both intervention families and examines how they can be strengthened in the Pakistani context.

1.2 Conceptualising Malnutrition

Malnutrition refers to deficiencies, excesses, or imbalances in a person's intake of energy and nutrients, and is conventionally divided into two broad categories: undernutrition and overnutrition. Undernutrition manifests in four principal forms. Stunting (low height-for-age) results from chronic nutritional deprivation, often beginning in utero and consolidating during the first two years of life. Wasting (low weight-for-height) reflects acute malnutrition arising from recent, severe weight loss; its most dangerous form, severe acute malnutrition, is defined by a weight-for-height z-score below -3 , a mid-upper-arm circumference (MUAC) below 115 mm, or the presence of nutritional oedema (WHO, 2023). Underweight (low weight-for-age) combines elements of both, while micronutrient deficiencies – often termed 'hidden hunger' – involve inadequate intake of essential vitamins and minerals such as iron, vitamin A, zinc, and iodine.

Overnutrition, by contrast, encompasses overweight, obesity, and diet-related non-

communicable diseases. Like many developing countries, Pakistan increasingly faces a 'double burden' of malnutrition, in which child undernutrition coexists with rising overweight in the wider population. The present survey concentrates on undernutrition in children, since it constitutes the dominant and most consequential burden in the Pakistani context.

1.3 Consequences of Child Malnutrition

The consequences of child malnutrition are profound and frequently irreversible. Nutritional deprivation during the first 1,000 days – from conception to a child's second birthday – impairs brain development, immune function, and physical growth, and nearly half of all deaths among children under five worldwide are attributable to undernutrition (Bhutta et al., 2013). Surviving children face elevated risks of infection, delayed cognitive development, poor school readiness, and reduced learning achievement. These individual losses aggregate into national ones: malnourished children complete fewer years of schooling, earn less as adults, and are more likely to raise malnourished children themselves, perpetuating an intergenerational cycle of poverty (World Bank, 2022). Addressing child malnutrition is therefore not merely a health imperative but a precondition for Pakistan's human capital development and long-term economic growth.

1.4 Problem Statement and Significance

Although Pakistan has made formal policy commitments to nutrition – including membership of the global Scaling Up Nutrition (SUN) movement, the Benazir Nashonuma conditional cash transfer and specialised nutritious food programme, and provincial school-meal pilots – implementation remains fragmented and outcomes have improved only slowly. The evidence base is similarly fragmented: studies of preventive interventions such as school feeding and curative interventions such as RUTF-based care are rarely synthesised together, and the potential of data-driven approaches to strengthen both remains underexplored. This survey addresses that gap by consolidating recent (2020–2025) evidence on both intervention families, analysing their effectiveness and constraints, and articulating

recommendations relevant to policymakers, programme implementers, and researchers. Given that modern nutrition programmes generate substantial operational data, the review also considers how techniques from data science and artificial intelligence can improve targeting, monitoring, and supply-chain management.

1.5 Research Objectives

The specific objectives of this study are:

1. To evaluate the effectiveness of school feeding programmes in improving the nutritional and educational outcomes of children in Pakistan (Iqbal et al., 2024).
2. To assess the effectiveness of RUTF-based interventions in the treatment of severe acute malnutrition.
3. To identify the implementation, financing, and supply-chain challenges constraining both interventions.
4. To propose evidence-based, data-driven recommendations for improving programme efficacy, sustainability, and scale (Hamid et al., 2024).

1.6 Research Questions

Consistent with these objectives, the review is organised around four research questions:

RQ1: How effective are school feeding programmes in improving nutritional and educational outcomes among Pakistani children?

RQ2: How effective are RUTF-based interventions in treating severe acute malnutrition (Hamid et al., 2024)?

RQ3: What barriers limit the implementation, scalability, and sustainability of these interventions in Pakistan?

RQ4: How can technological integration and policy support strengthen nutrition programming in Pakistan?

1.7 Organisation of the Paper

The remainder of the paper is organised as follows. Section 2 reviews the literature on school feeding, RUTF-based interventions, and data-driven nutrition programming, and identifies the research gap. Section 3 details the research methodology, including the search strategy, selection criteria, quality appraisal, and analytical framework. Section 4 presents the findings, organised into six themes and mapped

to the research questions. Section 5 discusses the findings, their policy and data-science implications, and the study's limitations. Section 6 sets out recommendations, and Section 7 concludes with directions for future work.

2. Literature Review

2.1 Global and Regional Context of Child Malnutrition

Child undernutrition remains a global emergency. The most recent joint estimates indicate that approximately 148 million children under five are stunted and 45 million are wasted worldwide, with South Asia accounting for a disproportionate share of both burdens (UNICEF, WHO, & World Bank, 2023). Economic analyses consistently show that nutrition interventions rank among the most cost-effective investments in development, generating high returns through improved health, cognition, and lifetime earnings (Bhutta et al., 2013). Within this landscape, Pakistan is a priority country: its stunting prevalence of 40.2% is among the highest in the region, and progress over the past two decades has been slow relative to neighbouring countries (Government of Pakistan & UNICEF, 2019; World Bank, 2022).

2.2 School Feeding Programmes

2.2.1 Concept and Typologies

The World Food Programme defines school feeding as the structured provision of food to schoolchildren, whether as on-site meals, fortified snacks and biscuits, or take-home rations conditional on attendance (WFP, 2022). Globally, an estimated 418 million children receive school meals every day, making school feeding the world's most extensive social safety net (WFP, 2022). A growing number of countries have adopted 'home-grown' school feeding models, which procure food from local smallholder farmers and thereby couple child nutrition objectives with agricultural and local economic development.

2.2.2 Educational Outcomes

A substantial body of evidence links school feeding to improved educational participation and performance. In a quasi-experimental evaluation, Aurino et al. (2020) reported

attendance improvements of nearly 20% among children participating in school feeding relative to comparison groups, alongside gains in enrolment and retention. Reviewing evidence from middle-income countries, Drake et al. (2021) concluded that regular access to nutritious school meals is associated with better concentration, classroom engagement, and academic achievement, with effects frequently strongest for girls and for children from the poorest households. The mechanism is intuitive: alleviating short-term hunger improves attention and cognitive functioning, while the transfer value of the meal lowers the effective cost of schooling for households.

2.2.3 Health and Nutritional Outcomes

School feeding also delivers measurable health benefits. Programmes that provide fortified meals or micronutrient-rich foods have been shown to improve dietary diversity and micronutrient sufficiency – particularly for iron and vitamin A – among participating children (Drake et al., 2021; WFP, 2022). Evidence for improvements in anthropometric indicators such as height-for-age is more mixed, reflecting the fact that stunting is largely determined before school age; nevertheless, school feeding remains an important vehicle for addressing micronutrient deficiencies and preventing further nutritional deterioration among school-age children.

2.2.4 Community Engagement

Beyond individual outcomes, school feeding programmes function as platforms for community engagement. Where parents, teachers, and local committees participate in planning, procurement, and oversight, programmes exhibit stronger ownership, accountability, and continuity, and communities become more receptive to broader nutrition and health messaging (WFP, 2022).

2.3 RUTF-Based Interventions

2.3.1 Composition and Rationale

Ready-to-Use Therapeutic Food is an energy-dense, micronutrient-fortified lipid paste – typically formulated from peanuts, milk powder, vegetable oil, sugar, and a vitamin–mineral premix – providing roughly 520–550 kilocalories per 100 grams. Because RUTF

requires no cooking, refrigeration, or dilution with water, it can be administered safely at home, which enables the outpatient, community-based management of acute malnutrition model now recommended internationally (WHO, 2023). This design shifted the treatment of severe acute malnutrition from congested inpatient facilities to communities, dramatically expanding coverage.

2.3.2 Clinical Effectiveness

The clinical evidence for RUTF is robust. Isanaka et al. (2020) report recovery rates of 75–90% among children with SAM treated with RUTF, comfortably exceeding the internationally accepted minimum performance standard of 75% recovery for therapeutic feeding programmes. Bazzano et al. (2021) similarly conclude that CMAM programmes built around RUTF achieve high recovery and low mortality at scale, at substantially lower cost per child than facility-based treatment. The 2023 WHO guideline consolidates this evidence, endorsing RUTF-based outpatient care as the standard of treatment for uncomplicated SAM (WHO, 2023).

2.3.3 Supply Chains and Access

The principal weaknesses of RUTF programming are logistical and financial rather than clinical. UNICEF, which procures roughly three-quarters of the global RUTF supply, has documented persistent challenges relating to long procurement lead times, freight costs, customs clearance, and in-country distribution (UNICEF, 2021). For countries such as Pakistan that rely substantially on imported RUTF, these vulnerabilities translate into exposure to currency fluctuations and periodic stock-outs, which interrupt treatment episodes and depress recovery rates. Sustained access therefore depends as much on supply-chain resilience and financing as on clinical protocols.

2.4 Technology and Data-Driven Approaches in Nutrition Programming

A newer strand of literature examines how digital technologies can strengthen nutrition programming. Gillespie et al. (2021) found that replacing paper-based systems with mobile data

collection tools significantly improved the accuracy and timeliness of programme reporting, enabling managers to detect problems and adapt in near real time. The World Food Programme has documented a parallel digital transformation of school feeding operations, including electronic beneficiary registries, digitised meal tracking, and real-time monitoring dashboards (WFP, 2023). These developments open the door to more advanced applications – predictive analytics for RUTF demand forecasting, machine-learning models to identify high-risk districts, and integration of programme data with national health information platforms – that remain largely untapped in Pakistan.

2.5 Research Gap

Taken together, the literature establishes the individual effectiveness of school feeding and RUTF but leaves three gaps that this survey addresses. First, few syntheses examine preventive and curative interventions jointly within the Pakistani context, even though children move along a single continuum from adequate nutrition through moderate to severe malnutrition. Second, implementation constraints – financing, supply chains, infrastructure, and community acceptance – are typically treated as afterthoughts rather than analysed systematically. Third, the role of data-

driven methods in improving programme delivery has received little attention in Pakistan-focused scholarship, a gap of particular relevance to the data sciences.

3. Research Methodology

3.1 Research Design

This study employs a qualitative systematic literature review with thematic synthesis. The review process was guided by the reporting principles of the PRISMA 2020 statement (Page et al., 2021), adapted to accommodate the inclusion of institutional 'grey' literature alongside peer-reviewed studies. A systematic review design was selected because the research questions concern the accumulated state of evidence rather than a single new empirical estimate, and because the available studies are methodologically heterogeneous – spanning quasi-experimental evaluations, clinical studies, evidence reviews, and institutional reports – which renders a quantitative meta-analysis inappropriate. Thematic synthesis permits rigorous integration of such heterogeneous evidence while preserving transparency about sources. Figure 1 summarises the overall methodological workflow, from the identification of sources through screening, full-text eligibility assessment, and quality appraisal to data extraction and thematic synthesis; each stage is elaborated in Sections 3.2–3.7.

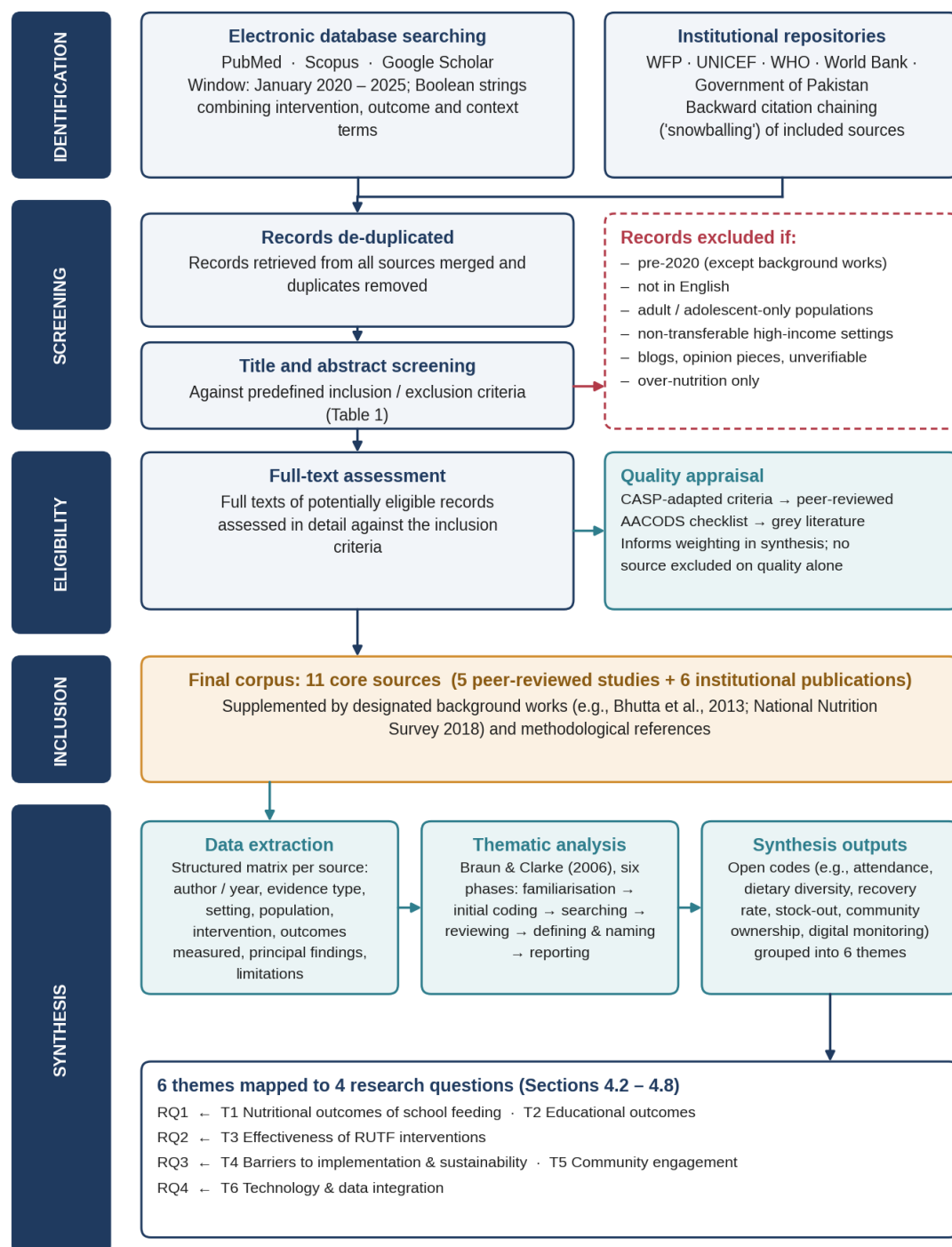


Figure 1. Methodological Workflow of the Systematic Review (Adapted from PRISMA 2020)

3.2 Data Sources and Search Strategy

Searches were conducted in PubMed, Scopus, and Google Scholar, complemented by targeted searches of the institutional repositories of the World Food Programme, UNICEF, the World Health Organization, the World Bank, and the Government of Pakistan. The review window

covered January 2020 to 2025 for the core corpus, while seminal earlier works (e.g., Bhutta et al., 2013) and national survey data (Government of Pakistan & UNICEF, 2019) were admitted for background and contextual framing. Search strings combined intervention, outcome, and context terms with Boolean

operators, for example: ("school feeding" OR "school meals") AND (Pakistan) AND (malnutrition OR stunting OR attendance); and ("ready-to-use therapeutic food" OR RUTF OR CMAM) AND ("severe acute malnutrition")

AND (Pakistan OR "low- and middle-income countries"). Backward citation chaining ('snowballing') of included sources was used to identify additional relevant material.

3.3 Inclusion and Exclusion Criteria

Predefined criteria, summarised in Table 1, governed the selection of sources.

Table 1. Inclusion and Exclusion Criteria

Dimension	Inclusion Criteria	Exclusion Criteria
Time frame	Published January 2020–2025 (designated seminal works and national surveys admitted for background only)	Published before 2020, except designated background works
Language	English	Non-English publications
Population	Children under five (RUTF/CMAM strand) and school-age children (school feeding strand)	Adult or adolescent-only populations
Geographic focus	Pakistan, or evidence from low- and middle-income countries transferable to Pakistan	High-income settings without transferable lessons
Publication type	Peer-reviewed studies; official reports of UN agencies, government, and multilateral institutions	Blogs, opinion pieces, and non-verifiable sources
Outcomes	Nutritional, educational, or implementation-related outcomes	Studies addressing over-nutrition only

3.4 Study Selection Process

Records retrieved from all sources were first de-duplicated. Titles and abstracts were then screened against the inclusion criteria, and the full texts of potentially eligible records were assessed in detail. This process yielded a final

corpus of eleven core sources – five peer-reviewed studies and six institutional publications – supplemented by the designated background works and methodological references. Table 2 summarises the selection stages.

Table 2. Stages of the Study Selection Process

Stage	Description
Identification	Systematic searches of PubMed, Scopus, and Google Scholar, plus institutional repositories (WFP, UNICEF, WHO, World Bank, Government of Pakistan), covering 2020–2025.
Screening	De-duplication of retrieved records, followed by title and abstract screening against the inclusion criteria in Table 1.
Eligibility	Full-text assessment of potentially eligible records; quality appraisal of empirical studies (CASP-based criteria) and grey literature (AACODS checklist).
Inclusion	Final corpus of eleven core sources: five peer-reviewed studies and six institutional publications, plus designated background and methodological references.

3.5 Data Extraction

For each included source, data were extracted into a structured matrix recording the author(s) and year, type of evidence, geographic setting, target population, intervention characteristics, outcomes measured, principal findings, and stated limitations. Extraction followed the same template for all sources to ensure comparability, and entries were re-checked against the original documents to minimise transcription error.

3.6 Quality Appraisal

The credibility of peer-reviewed studies was appraised using criteria adapted from the Critical Appraisal Skills Programme (CASP) checklists, attending to the clarity of research questions, the appropriateness of the design, and the validity of the conclusions drawn. Institutional and grey literature was appraised using the AACODS checklist, which evaluates Authority, Accuracy, Coverage, Objectivity, Date, and Significance. No source was excluded solely on quality grounds, but appraisal results informed the weight assigned to each source during synthesis.

3.7 Data Analysis

Extracted data were analysed using thematic analysis following the six-phase approach of Braun and Clarke (2006): familiarisation with the data; generation of initial codes; searching for themes; reviewing themes; defining and naming themes; and producing the report. Open codes (for example, 'attendance', 'dietary diversity', 'recovery rate', 'stock-out', 'community ownership', and 'digital monitoring') were

iteratively grouped into six higher-order themes, which structure the presentation of findings in Section 4 and are mapped explicitly to the research questions in Table 4.

3.8 Ethical Considerations

The study draws exclusively on published secondary sources and involves no human participants, personal data, or interventions; formal ethical approval was therefore not required. Ethical practice was nonetheless observed through accurate attribution of all sources, faithful representation of authors' findings, transparent reporting of the review procedure, and explicit acknowledgement of the study's limitations.

4. Findings and Analysis

4.1 Overview of the Reviewed Evidence

Table 3 summarises the eleven core sources included in the review. The corpus spans quasi-experimental and clinical studies, evidence reviews, normative guidelines, and institutional reports, and collectively addresses both intervention families across nutritional, educational, and implementation dimensions. Six themes emerged from the thematic analysis and are presented in the subsections that follow. Figure 2 profiles the composition of the corpus: the school feeding and RUTF strands are represented in similar proportions, peer-reviewed and institutional sources are balanced within each strand, and nine of the eleven sources were published in 2021 or later, reflecting the recency of the evidence base.

Table 3. Summary of Core Sources Included in the Review

Source	Evidence Type	Focus Area	Key Contribution
Aurino et al. (2020)	Quasi-experimental study	School feeding and education	Attendance improvements approaching 20% among participating children; nutrition-education linkages.
Drake et al. (2021)	Peer-reviewed review	School feeding in middle-income countries	Nutritious school meals linked to improved concentration, engagement, and academic performance; policy design lessons.
Bazzano et al. (2021)	Peer-reviewed study	CMAM / RUTF	Community-based management with RUTF is effective and feasible

Source	Evidence Type	Focus Area	Key Contribution
			at scale, at lower cost than inpatient care.
Isanaka et al. (2020)	Peer-reviewed study	RUTF treatment outcomes	Recovery rates of 75–90% among children with severe acute malnutrition treated with RUTF.
Gillespie et al. (2021)	Peer-reviewed study	Data-driven nutrition programming	Mobile data collection improved the accuracy and timeliness of programme reporting.
WFP (2022)	Institutional report	Global school feeding	418 million children receive school meals globally; typologies and programme frameworks.
WFP (2023)	Institutional report	Digital tools in school feeding	Digitalisation of registries, meal tracking, and real-time monitoring of school feeding operations.
UNICEF (2021)	Institutional report	RUTF supply and logistics	Procurement dominance, lead times, and risks of import dependence in RUTF supply chains.
UNICEF (2023)	Institutional report	Pakistan nutrition programme	Programme coverage, priorities, and constraints in the Pakistani context.
WHO (2023)	Normative guideline	Management of acute malnutrition	Updated recommendations endorsing RUTF-based, community-level outpatient care for uncomplicated SAM.
World Bank (2022)	Institutional report	Economic burden of malnutrition	Economic costs of stunting to Pakistan and the investment case for nutrition.

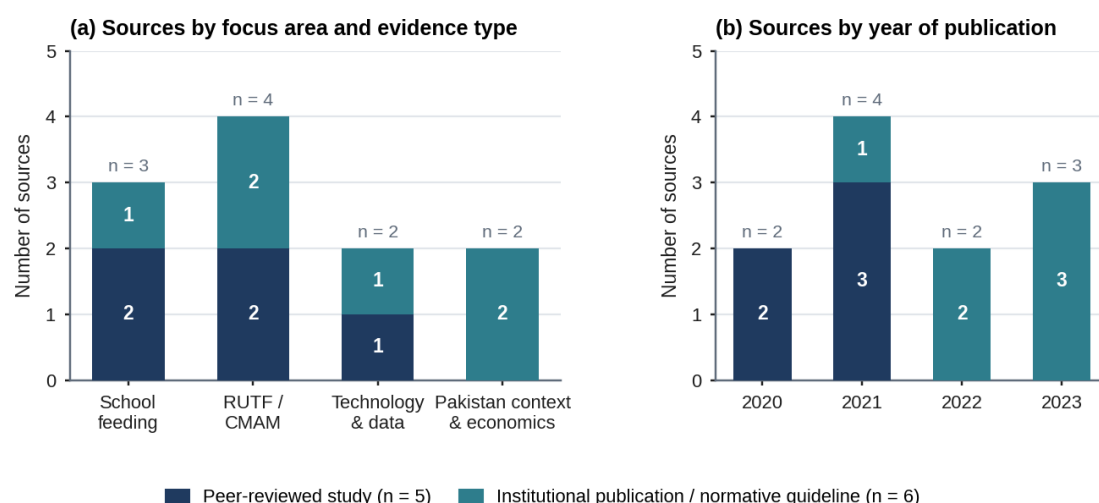


Figure 2. Composition of the Core Corpus by Focus Area, Evidence Type, and Year of Publication (n = 11)

4.2 Theme 1: Nutritional Outcomes of School Feeding

The reviewed evidence indicates consistent improvements in the nutritional status of children participating in school feeding programmes. Participation is associated with greater dietary diversity and improved intake of key micronutrients, notably iron and vitamin A, particularly where meals are fortified or deliberately designed for nutrient density (Drake et al., 2021; WFP, 2022). Reductions in short-term hunger are reported almost universally and underpin many of the downstream educational effects. Effects on anthropometric indicators are more modest, which is expected given that linear growth faltering is concentrated in the first two years of life; the appropriate interpretation is that school feeding protects and consolidates nutrition among school-age children rather than reversing established stunting.

4.3 Theme 2: Educational Outcomes – Attendance, Retention, and Learning

Educational effects constitute the strongest and most consistent finding for school feeding. Aurino et al. (2020) document attendance gains approaching 20% among participating children, together with lower dropout and higher retention. Drake et al. (2021) report improved concentration, engagement, and academic performance among children receiving

nutritious school meals, with disproportionate benefits for girls and for the poorest households. These findings position school feeding as a rare instrument that advances health and education objectives simultaneously – a property of particular value in Pakistan, where more than twenty million school-age children remain out of school and where hunger is a documented barrier to attendance.

4.4 Theme 3: Effectiveness of RUTF Interventions

The evidence on RUTF is unambiguous with respect to clinical effectiveness. Recovery rates of 75–90% among children treated for severe acute malnutrition (Isanaka et al., 2020) meet or exceed international minimum standards, and community-based delivery achieves these outcomes at lower cost and far greater coverage than inpatient care (Bazzano et al., 2021; WHO, 2023). The reviewed sources attribute this success to the product's high energy density, its safety in home settings, and its ease of administration by caregivers, which jointly allow uncomplicated SAM to be treated without hospitalisation and reserve scarce inpatient capacity for complicated cases. Figure 3 consolidates the principal quantitative evidence underlying Themes 1–3, situating the outcomes reported for both interventions against the

baseline burden of undernutrition among Pakistani children under five.

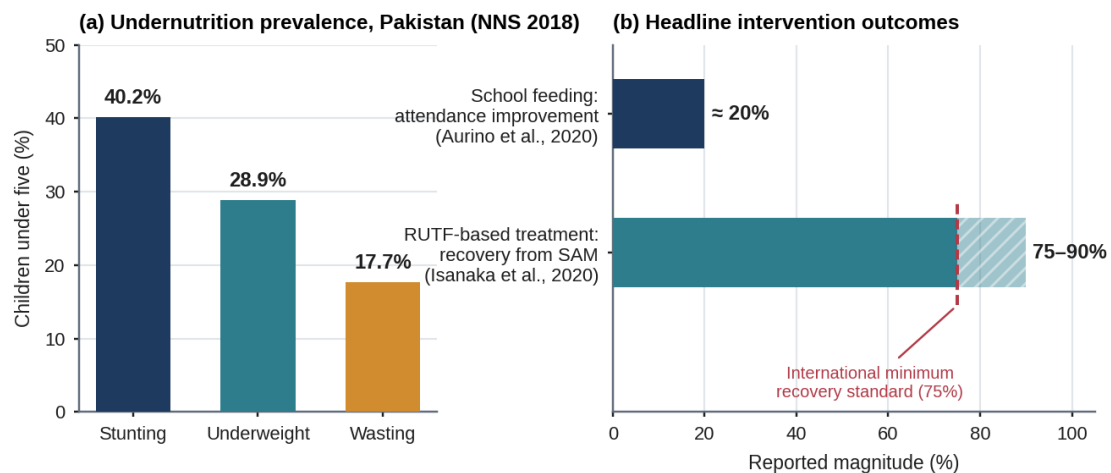


Figure 3. Quantitative Evidence Synthesised from the Review: (a) Prevalence of Undernutrition among Pakistani Children under Five (NNS 2018); (b) Headline Outcomes Reported for School Feeding (Aurino et al., 2020) and RUTF-Based Treatment (Isanaka et al., 2020)

4.5 Theme 4: Barriers to Implementation and Sustainability

Despite strong effectiveness evidence, the reviewed sources converge on a set of systemic barriers. Financing is the most fundamental: both intervention families in Pakistan rely heavily on donor funding, exposing programmes to volatility and undermining long-term planning (UNICEF, 2023; World Bank, 2022). Supply-chain fragility is the second: dependence on imported RUTF entails long lead times, freight and customs costs, and vulnerability to currency depreciation, with stock-outs directly interrupting treatment episodes (UNICEF, 2021). Infrastructural constraints — storage, kitchen facilities, and safe water and hygiene in schools — limit the quality of school feeding, while limited community awareness of malnutrition and of available services depresses both demand and early treatment-seeking. Finally, weak and fragmented monitoring systems impede evidence-based management, a gap that the technology literature addresses directly (Gillespie et al., 2021).

4.6 Theme 5: Community Engagement and Ownership

Sources consistently identify community involvement as a determinant of programme

success. Where communities participate in planning, food procurement, preparation, and oversight — for example through school management committees — programmes display stronger ownership, better accountability, higher acceptance of interventions such as RUTF, and greater resilience when external support fluctuates (Bazzano et al., 2021; WFP, 2022). Engagement also produces spillover effects, as participating households absorb and transmit broader nutrition knowledge within their communities.

4.7 Theme 6: Technology and Data Integration

The reviewed evidence indicates that digital tools materially improve programme delivery. Mobile data collection increases the accuracy and timeliness of reporting (Gillespie et al., 2021), while digitised registries, meal tracking, and dashboards give managers near-real-time visibility over school feeding operations (WFP, 2023). The sources reviewed stop short, however, of the more advanced applications now feasible: predictive modelling of RUTF demand to pre-empt stock-outs, machine-learning identification of high-risk districts using survey and administrative data, and interoperability with national health information systems. This constitutes a significant opportunity space at the

intersection of nutrition programming and data science.

4.8 Alignment of Findings with the Research Questions

Table 4 maps the six themes and their principal sources to the research questions posed in Section 1, confirming that each question is addressed by multiple independent sources. Figure 4 complements the table with an evidence

map indicating which core sources inform each theme, based on the citations in Sections 4.2–4.7. No theme rests on a single source; implementation barriers (Theme 4) draw on the widest range of evidence; and four sources – Bazzano et al. (2021), Drake et al. (2021), Gillespie et al. (2021), and WFP (2022) – contribute to more than one theme, reflecting the interdependence of nutritional, educational, and implementation dimensions.

Table 4. Mapping of Research Questions to Themes and Principal Sources

RQ	Theme(s) Addressed	Principal Sources
RQ1	Theme 1 (nutritional outcomes) and Theme 2 (educational outcomes) of school feeding	Aurino et al. (2020); Drake et al. (2021); WFP (2022)
RQ2	Theme 3 (effectiveness of RUTF interventions)	Isanaka et al. (2020); Bazzano et al. (2021); WHO (2023)
RQ3	Theme 4 (implementation barriers) and Theme 5 (community engagement)	UNICEF (2021); UNICEF (2023); World Bank (2022); Bazzano et al. (2021)
RQ4	Theme 6 (technology and data integration)	Gillespie et al. (2021); WFP (2023)

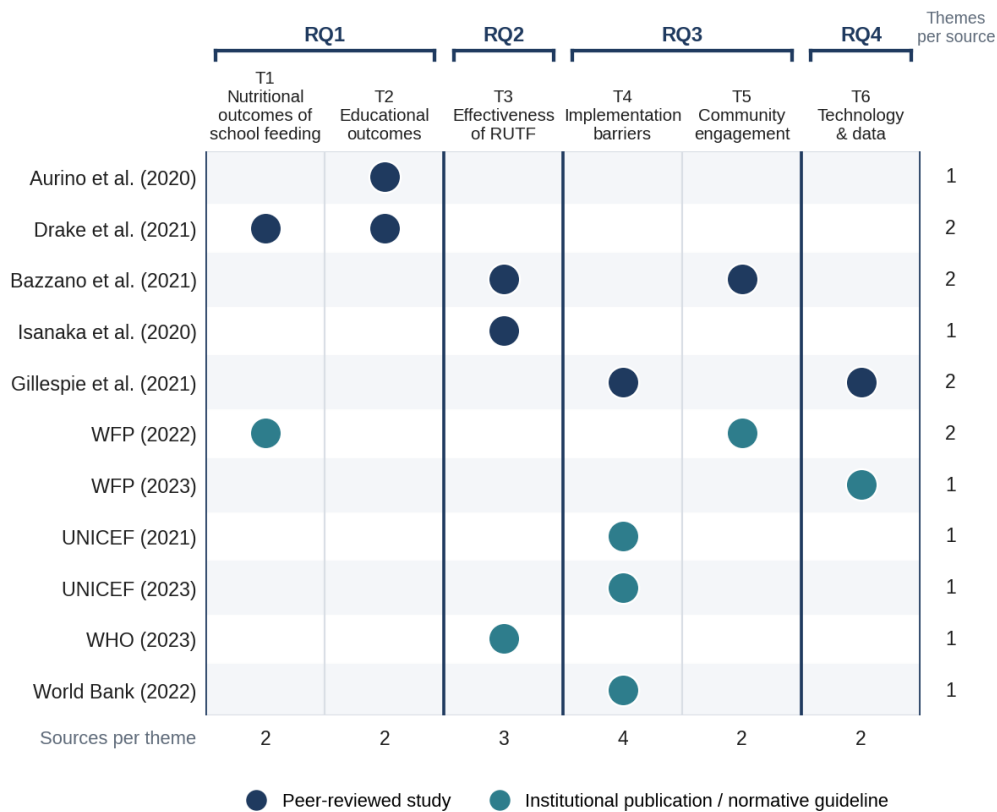


Figure 4. Evidence Map of Core Sources against the Six Themes and Four Research Questions

5. Discussion

5.1 Interpreting the Evidence: A Continuum of Care

The central interpretive conclusion of this review is that school feeding and RUTF are complements, not alternatives. School feeding operates preventively across the broad population of school-age children, protecting nutritional status and drawing children into education; RUTF operates curatively at the acute end of the spectrum, rescuing children whose condition has become life-threatening. Pakistan's malnutrition burden spans this entire

continuum, and the evidence reviewed here implies that neither intervention alone can be sufficient. An integrated architecture – universal or targeted school feeding, active community screening, and reliable RUTF-based treatment for identified SAM cases – aligns with the direction of the WHO's 2023 guideline and with Sustainable Development Goals 2 (Zero Hunger), 3 (Good Health and Well-being), and 4 (Quality Education). Figure 5 depicts this integrated continuum of care, together with the cross-cutting enablers identified in the review and elaborated in Sections 5.2–5.4.

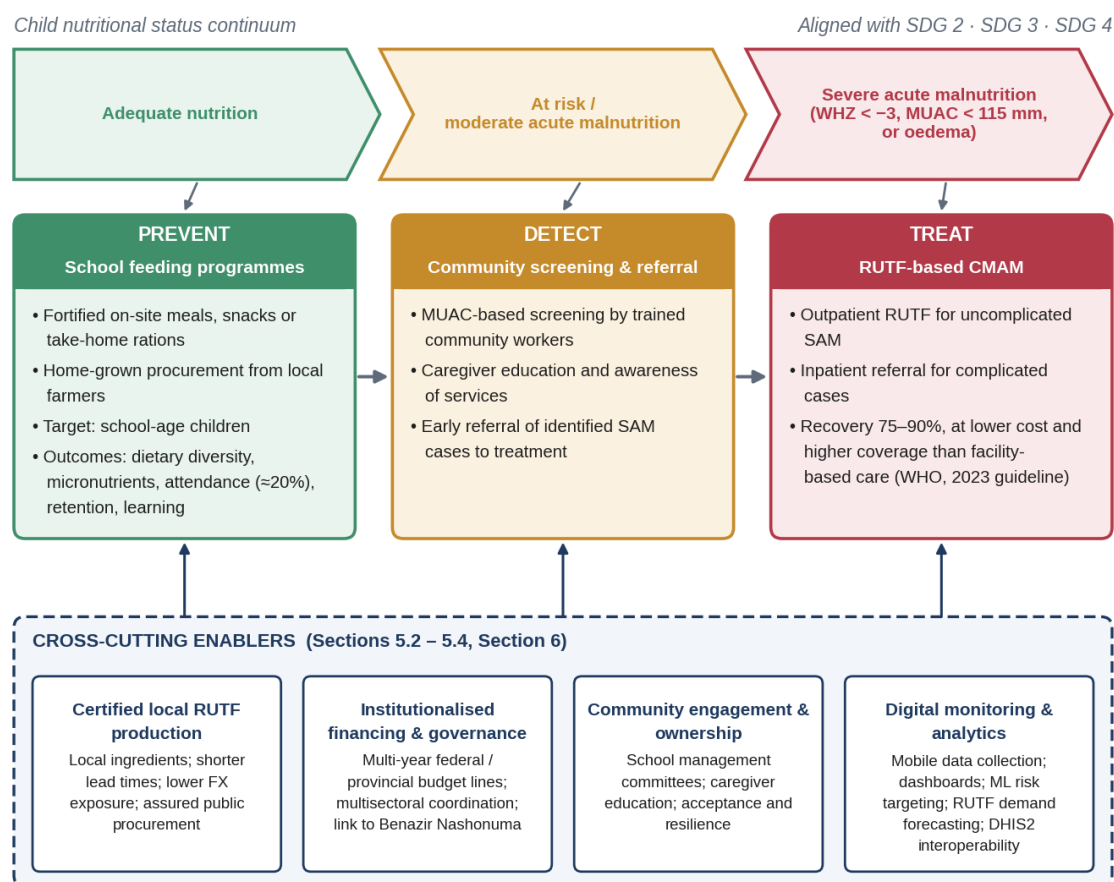


Figure 5. Integrated Continuum of Care for Child Malnutrition in Pakistan Derived from the Review Findings

5.2 Local Production and Sustainability

The review's findings on supply-chain fragility point directly to local RUTF production as a strategic priority. Domestic manufacture using locally available ingredients can shorten lead times, reduce freight and foreign-exchange exposure, lower unit costs, and create agro-industrial employment, provided that products meet international quality and safety specifications (Bhutta et al., 2013; UNICEF, 2021). Formulations adapted to local ingredient availability – including chickpea-based recipes developed for South Asian contexts – merit particular attention. A credible localisation agenda requires investment in manufacturing capacity, quality certification, and assured public procurement so that domestic producers face predictable demand.

5.3 Policy and Institutional Support

Sustainability ultimately depends on institutionalisation. Since the 18th Constitutional Amendment devolved health and education to the provinces, effective nutrition action in Pakistan requires provincial ownership backed by federal coordination. The findings support embedding school feeding within provincial education-sector plans and budgets rather than treating it as a donor project, and financing RUTF procurement through regular health budgets with multi-year commitments. Alignment with existing social-protection platforms – such as the Benazir Nashonuma programme targeting the first 1,000 days – would connect preventive, curative, and safety-net instruments into a coherent national nutrition architecture.

5.4 Implications for Data Science and Artificial Intelligence

For a data sciences audience, the findings identify concrete, high-value applications. First, monitoring: mobile data collection and dashboard-based management are proven and should become standard practice (Gillespie et al., 2021; WFP, 2023). Second, targeting: machine-learning models trained on national survey, administrative, and geospatial data could identify the districts and union councils at greatest risk of acute malnutrition, enabling anticipatory rather than reactive response. Third, supply chains: time-series forecasting of RUTF demand, integrated with logistics management information systems, could substantially reduce stock-outs. Fourth, interoperability: linking programme data with national health information platforms such as DHIS2 would create longitudinal visibility over child nutrition. Each of these applications, however, involves the personal data of children and therefore demands rigorous data governance, privacy protection, and ethical oversight.

5.5 Limitations of the Study

Several limitations qualify these findings. The review relies exclusively on published secondary sources and is therefore exposed to publication bias, since unsuccessful programmes are less likely to be documented. The heterogeneity of study designs precluded quantitative meta-analysis, so effect sizes are reported as found rather than statistically pooled. Pakistan-specific experimental evidence remains thin, obliging partial reliance on evidence from comparable low- and middle-income settings whose transferability cannot be assumed. Institutional sources, while authoritative, are produced by implementing agencies and may present programmes favourably. Finally, the nutrition landscape in Pakistan is evolving rapidly – particularly following the 2022 floods – and some quantitative estimates may date quickly.

6. Recommendations

On the basis of the synthesised evidence, six recommendations are advanced:

1. **Scale up school feeding through home-grown models.** Expand provincial school-meal

programmes using locally procured, fortified foods, prioritising districts with the highest malnutrition and out-of-school rates, and embed them in education-sector budgets.

2. **Develop certified domestic RUTF production.** Support local manufacturers – through technical assistance, quality certification, and assured public procurement – to produce RUTF from local ingredients, reducing costs, lead times, and import dependence.

3. **Institutionalise financing and governance.** Establish multi-year federal and provincial budget lines for school feeding and SAM treatment, coordinated through a multisectoral nutrition governance structure spanning health, education, agriculture, and social protection.

4. **Deploy digital monitoring and analytics.** Standardise mobile data collection, real-time dashboards, and demand forecasting for RUTF supply chains, with integration into national health information systems and strong data-protection safeguards.

5. **Invest in community engagement.** Strengthen school management committees, caregiver education, and community-level screening (including MUAC-based screening by trained community workers) to raise awareness, early detection, and programme ownership.

6. **Build the evidence base.** Commission longitudinal, Pakistan-specific evaluations and cost-effectiveness studies of both intervention families, including rigorous evaluation of digital and AI-enabled delivery models.

7. Conclusion and Future Work

Child malnutrition in Pakistan is severe, persistent, and consequential, but it is not intractable. The evidence synthesised in this survey shows that two well-understood instruments already exist: school feeding programmes that measurably improve children's nutrition, attendance, and learning, and RUTF-based community treatment that recovers 75–90% of children from severe acute malnutrition. The binding constraints are not clinical but systemic – financing volatility, import-dependent supply chains, infrastructural gaps, and weak data systems. Accordingly, the path forward combines the scale-up of proven

interventions with structural reform: local RUTF production, institutionalised public financing, deliberate community engagement, and the systematic use of digital and data-driven tools.

Future research should pursue three directions. First, rigorous Pakistan-specific impact and cost-effectiveness evaluations of integrated preventive-curative programming. Second, the development and validation of machine-learning models for malnutrition risk prediction and RUTF demand forecasting using national survey and administrative data. Third, implementation research on data governance frameworks appropriate for child nutrition data. Pursued together, these directions would allow Pakistan not merely to treat malnutrition more effectively, but to anticipate and prevent it – converting today's crisis into a foundation for healthier, better-educated future generations.

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