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Nutrition interventions for children aged less than 5 years following natural disasters: a systematic review

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ABSTRACT

Objectives: The objective of this paper was to review various nutritional interventions targeted at under-five children in countries that had suffered from natural disasters and to analyse their effect on nutrition-related outcomes.

Design: Systematic review.

Setting: Countries that had suffered from natural disasters.

Participants: Children aged <5 years who were given any nutritional intervention to improve overall nutritional status after a natural disaster.

Primary and secondary outcome measures: Primary nutrition-related outcomes were stunting, wasting and underweight. The secondary nutrition-related outcome was anaemia.

Results: Of the 1218 studies that the reviewers agreed on, five matched the inclusion criteria and were included in this narrative synthesis. Four studies were longitudinal and one was cross-sectional in design. Food supplementation was an integral part of nutritional interventions in all the included studies. The most consistent nutritional outcome in all five included studies was reduced prevalence of wasting, followed by reduced prevalence of underweight in four, stunting in three and anaemia in one of the five included studies. The largest reduction in the prevalence of wasting and underweight was reported by the study in Sri Lanka. Overall, the quality of evidence ranged from moderate to weak.

Conclusions: Integrated nutrition interventions using locally available health resources yielded the best results. However, sound evidence on the most effective interventions is still lacking. Intervention studies with comparison groups are necessary to obtain more robust evidence on the effectiveness of nutrition interventions.

Strengths and limitations of this study

- The study is relevant to current circumstances, where frequent natural disasters have put nutritional status of children at risk.
- The findings could be useful for preparedness and planning of nutrition response to a major disaster.
- The study provides current evidence on the effectiveness of nutrition interventions for children <5 years old following natural disasters and implications for future research.
- The literature in the subject area is limited and therefore we are not able to obtain strong evidence. We did not find any randomised controlled trials (RCTs), cluster RCTs or quasi-experimental studies on nutritional interventions for under-five children after natural disasters.
- The selected studies were conducted in different regions and there is a risk of regional variability. Also, improvement in the nutritional status of children cannot be attributed to the interventions alone.

INTRODUCTION

Any natural disaster, such as earthquake, drought, flood, landslides, cyclone, tsunami, hurricane and tornado puts the nutritional status of people at risk. There is large-scale destruction of houses, stored food and livestock and exposure of people living in temporary shelters to harsh weather. A state of nutritional emergency exists when there is the risk of, or actual rise in, mortality due to acute malnutrition.[1] Interruption in regular food supply, restricted access to health services, and diversion of family income has proved detrimental to vulnerable populations, especially children.[2 3]

According to joint child malnutrition estimates, the global prevalence of wasting—a measure of acute malnutrition—is ~7.5% and that of severe wasting is 2.4%. The highest rates of wasting have been reported from lower- and middle-income countries (11.6%).[4] Moreover, during emergencies, the prevalence of acute malnutrition, including severe acute malnutrition (SAM), can be as high as 10–15%.[1] Higher rates of acute malnutrition have been recorded after emergencies in East Africa and countries bordering the Sahara, with lower rates in Southern Africa and Asia. Similarly, higher rates have

been reported from South Asian countries such as Bangladesh and Nepal.[5] Higher rates of malnutrition before an emergency indicate greater vulnerability to malnutrition and a higher risk of mortality among under-five children. In countries where the rate of stunting/underweight is already high, natural disasters further aggravate the risk of malnutrition and mortality in newborns and growing children.

There is scant evidence on the nutritional outcome of natural disasters. Multiple studies worldwide have shown that natural disasters have negative effects on the growth of children.[6–8] A study conducted by Pörtner *et al*[7] found that each disaster occurrence reduced children's height-for-age Z scores by 0.1–0.2 units, increasing the prevalence of stunting. Also there was a rise in the prevalence of wasting among children in Aceh after the tsunami.[9] Nutritional consequences may differ depending on the nature of the disaster. For example, the consequences of floods on nutritional status have been rarely investigated.[10] Floods have been associated with malnutrition in infants and young children in rural areas and urban slum dwellings in developing countries.[11] Studies conducted in rural parts of Eastern India suggested that exposure to floods can be associated with a rise in both stunting and wasting among children.[12 13]

Nutritional interventions such as supplementary and therapeutic feeding programmes are very important during the critical period after natural disasters. Supplementary feeding programmes are particularly concerned with groups such as pregnant women, lactating mothers and moderately malnourished children to prevent further deterioration and mortality. Therapeutic feeding programmes target severely malnourished children.[14] A blanket supplementary food programme is needed when the malnutrition rate exceeds 10–15% in the presence of other aggravating factors.[15] Micronutrient deficiencies are very common during calamities, so food rations are fortified with essential micronutrients. Cash transfer, rather than food assistance, is being considered as an effective means of supporting the vulnerable in protracted humanitarian crises.[5] Although the humanitarian approach is prioritised in the short term, it should build on and strengthen local systems, as health impacts of most major disasters may persist over months/years regardless of event and health outcome.[5 16] Different nutritional interventions have been applied in post-natural disaster settings worldwide, but a knowledge gap exists between every intervention and its impact and this is a major hindrance to further advances.[5]

Despite the common occurrence of natural disasters, insufficient research evidence has been compiled on different nutritional interventions in such settings. The aim of this study was to review various nutritional interventions targeted at under-five children in countries that have suffered from different natural disasters and to analyse their effect on nutrition-related outcomes.

METHODS

This systematic review was conducted on nutrition intervention studies performed after natural disasters. The protocol of this systematic review has already been published[17] (see online supplementary file 1).

A review protocol based on PICO (population, intervention, comparators and outcomes) questions was developed. The population was defined as children below 5 years of age in settings where a natural disaster had taken place. The comparators included comparison groups of the intervention studies. The outcomes included anthropometric measures such as weight for height, height for age, weight for age and anaemia.

Nutrition interventions and nutrition-related outcomes

Nutrition intervention was defined as any type of intervention for children aged <5 years to improve their overall nutritional status. Different types of intervention include food fortification, supplementation, and behavioural and regulatory interventions which have an impact on nutrition outcomes.[18] In this review, the primary nutrition-related outcomes were stunting, wasting and underweight. Children with a height-for-age Z score below −2SD from the median of the WHO reference population were defined as stunted. Children with a weight-for-height Z score below −2SD were defined as wasted. Children with a weight-for-age Z score below −2SD were defined as underweight.[19] The secondary nutrition-related outcome was anaemia, which was defined as haemoglobin concentration below 11 g/dL for children aged <5 years.[20]

Study designs

We included longitudinal and cross-sectional studies with a comparison group in this study. We had intended to include randomised controlled trials (RCTs) and cluster RCTs to measure the effectiveness of the interventions. As an amendment to our published protocol, we had to limit ourselves to observational studies.

Data sources for existing review

Three researchers independently searched for any existing review or submitted protocol listed in the following databases: Cochrane Library or the Cochrane Database of Systematic Reviews, Abstracts of Reviews of Effects, National Institute for Health and Care Excellence, Educational Resources and Information Center, and Campbell Library of Systematic Reviews.

Data collection

Consensus was built among the reviewers by discussion before the studies were chosen. Three reviewers (PMSP, RD and HS) independently searched for the titles and abstracts and selected the studies that were relevant. Records of the studies were managed electronically using Mendeley Desktop software V.1.14. All three reviewers read the titles, abstracts and full texts of the selected studies to verify that they matched the inclusion

criteria. None of the reviewers were blinded to the name of the authors, affiliations or institutions, or journal of publication. Any disagreement among the reviewers was resolved through discussion. The procedure of study selection followed PRISMA guidelines.[21]

Registration details

We registered the protocol of our systematic review on 1 June 2015 at PROSPERO. The registration number for this review is CRD42015023243 available at http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42015023243#.VZIYmKZqbxY.

Search strategy

We searched PubMed/Medline, Cumulative Index to Nursing and Allied Health Literature, Health Internetwork Access to Research Initiative and Google Scholar. We also searched WHO databases, and the related links: Emergency Nutrition Network database, Global Nutrition Cluster, UN Standing Committee on Nutrition, United Nations Children's Fund and United Nations Office for the Coordination of Humanitarian Affairs. Relevant studies from the reference lists of the above sources were searched.

The Boolean method was used to search on the following keywords: nutrition intervention, natural disaster, natural disasters, under five children, under 5, under-5, acute malnutrition, stunting, wasting, underweight, anaemia. The initial search strategy for PubMed was ((((((((((((Randomised controlled trial) OR Cluster randomised controlled trial) AND Nutritional intervention) OR nutrition intervention) AND Natural disaster) OR natural disasters) AND under five) OR under 5) OR under-5) AND acute malnutrition) OR stunting) OR wasting) OR underweight) OR anaemia (see online supplementary file 2).

Three reviewers independently searched the database. We limited the search to a 15-year publication window (January 2000 to December 2015).

Inclusion and exclusion criteria

We included children aged 6 months to 59 months from natural disaster settings. Studies published in English from January 2000 to December 2015 were included in our review. We included all kinds of natural disasters such as earthquake, landslides, tsunami, flood, hurricane and drought. We included quantitative study designs that had a clear intervention.

Interventions that were indirectly related to nutrition outcomes were excluded from the review—for example, cash transfer improved the nutritional status of children from poor households in Niger following episodes of drought in 2005.[22] We also excluded any other humanitarian crisis that was not directly related to natural disasters.

Quality assessment

We graded the quality of evidence using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) guidelines.[23–25] The three reviewers carefully assessed the included studies independently and agreed on the final grading with strong inter-reliability. We categorised the evidence as very strong, strong, moderate and weak based on the study design, strengths and limitations, population size and effect size of pooled results (table 1). We adapted the quality-rating scheme from the Cochrane guidelines on quality assessment.[26]

Risk of bias

In this review, we used the Risk of Bias Assessment for Non-Randomised Studies (RoBANS) tool.[27] The risk of bias was evaluated under five different domains: selection of participants, confounding variables, intervention (exposure) measurement, blinding of outcome assessment, incomplete outcome data, and selective outcome reporting.

Data synthesis

Meta-analysis was planned initially, but owing to the heterogeneity and quality of the studies, we had to limit ourselves to narrative synthesis.[28] Most of the studies were descriptive in nature. Few studies that used statistical analysis had different study outcomes.

RESULTS

A total of 1218 articles were agreed upon, of which 670 were from PubMed and the others from the aforementioned databases. After careful screening, five studies were included in the final narrative analysis. Figure 1 shows the flowchart of the studies identified and the process of screening.

All the five studies included in this review had a clear objective, intervention, study design, sample size and sampling method. Some of the studies that fit our inclusion criteria also had results for age groups beyond the set criteria.

Study setting and population

Of the five studies selected, four were carried out in Asia and one in Africa. The lowest age group of children included was 6 months in three of the studies.[29–31] One study included children within the age group 12–59 months, whereas the others included all children below 5 years of age.[32 33]

Type of natural disaster

The studies from India and Kenya were performed after episodes of drought which occurred in 2002 and 2011, respectively.[29 33] Similarly, the study from China was performed after the earthquake in Wenchuan County in 2008.[31] The study from Bangladesh was conducted after the super cyclonic storm Sidr in 2007.[32] The study from

Table 1 Characteristics of included studies

Author	Country	Type of natural disaster	Aim/objective of the study	Design	Sampling method	Population age (number enrolled)	Intervention	Frequency and timing of Assessment of Nutritional Status	Comparator	Wasting	Stunting	Underweight	Anaemia	Quality of evidence
Dong *et al*[31]	China, Wenchuan	Earthquake 2008	To evaluate the efficiency of providing daily complementary food supplements	Longitudinal	Probability proportional to size sampling	6–18 months (n=1019)	Daily complementary food supplementation (referred to as Ying Yang Bao in Chinese) containing multiple vitamins and minerals. Duration of intervention: 1.5 years	Three times at 6, 12 and 18 months after start of intervention	Within-group comparison (pre and post intervention)	Significantly improved from 3.5% to 1.7% (p<0.05)	Significantly improved from 8.9% to 5% (p<0.05)	Significantly improved from 4.5% to 3.3% (p<0.05)	Significantly decreased from 74.3% to 37.4% (p<0.05)	Moderate
Jayatissa *et al*[30]	Sri Lanka, Jaffna	Tsunami 2004	To assess the impact of community-based management of acute malnutrition among children under 5 years of age and its operational challenges	Longitudinal	Probability proportional to size sampling	6–59 months (n=3638 in phase I, 38953 in phase II, 43221 in phase III and 282 in end line survey)	Interventions were given in two phases. First phase: Community awareness and complementary food supplementation Hospitalised malnourished children were given formula 75 (F75) during stabilisation phase and formula 100 (F100) alternating with RUTF in transition phase. During follow-up, children were provided with RUTF. They also received other services (deworming, vitamin A supplementation, age-appropriate immunisation, etc) Duration of intervention: 13 months	Once 2 years after the intervention	None	Improved from 18% to 9.6% (no p value)	Improved from 18.2% to 15.2% (no p value)	Improved from 30.8% to 14.4% (no p value)	No details	Weak

Continued

Table 1 Continued

Author	Country	Type of natural disaster	Aim/objective of the study	Design	Sampling method	Population age (number enrolled)	Intervention	Frequency and timing of Assessment of Nutritional Status	Comparator	Wasting	Stunting	Underweight	Anaemia	Quality of evidence
Rah *et al*[32]	Bangladesh (Barguna, Bagerhat, Patuakhali and Pirojpur districts)	Cyclone Sidr 2007	To document the experience and findings of micronutrient powder programme implemented as part of the emergency response	Cross-sectional with comparison group	Multistage random sampling	12–59 months (n=429 intervention group, n=428 control group)	Micronutrient powder called Pushtika in sachets was given to children under 5 years on every other day for the intervention group Duration of intervention: 6 months	Once, 1 month after intervention	12–59 month age children from unions in the same sub-district with similar socioeconomic status, food security and nutritional status	Within intervention group, prevalence of wasting was 6% for <75% sachet consumption and 12.9% for ≥75% sachet consumption. No details for the control group	Within the intervention group, those who consumed at least 75% of the micronutrient powder sachets had significantly lower prevalence of stunting than those who consumed less than 75% of the sachets (p<0.05)	Within intervention group, prevalence of underweight was 29.8% for <75% sachet consumption and 30.4% for ≥75% sachet consumption. No details for the control group	No significant difference in prevalence of anaemia between control and intervention group (79% and 82%, respectively)	Moderate
Kumar and Bhawani[33]	India; Rajasthan	Drought 2002	To assess the impact of Nutrition Care Centres (NCCs) 6 months after the intervention	Longitudinal	Stratified random sampling	Below 5 years (n=3206 in initial survey, n=1775 in repeat survey)	NCCs were set up in selected villages to provide targeted feeding and care to these children as per WHO guidelines. Local community was involved in running these NCCs Duration of intervention: 6 months	Once, 1 month after intervention	No control group	Baseline prevalence 27.3%; no details on wasting after intervention	No details	Prevalence of severe under weight children (3 SD below M) reduced from 32.9% to 26.1%	No details	Weak
CDC US[29]	Kenya, Turkana and Wajir counties	Drought 2011	To determine if the blanket supplementary feeding programme improved nutritional status among children enrolled in the programme	Longitudinal	Probability proportional to size sampling	6–36 months (n=757 in Turkana and n=1012 in Wajir)	Blanket supplementary feeding programme as a whole (ration, education and systematic treatment) on preventing deterioration of nutritional status among children. Duration of intervention: 7 months	Five times, during each of the five ration distribution cycles over 8 months	Within-group comparison between two counties in both intervention areas	In Turkana WHZ significantly improved from −0.92 to −0.70 In Wajir WHZ significantly improved from −0.89 to −0.52 (p<0.05)	No details	No details	No details	Moderate

RUTF, ready-to-use therapeutic food; WHZ, weight-for-height Z score.

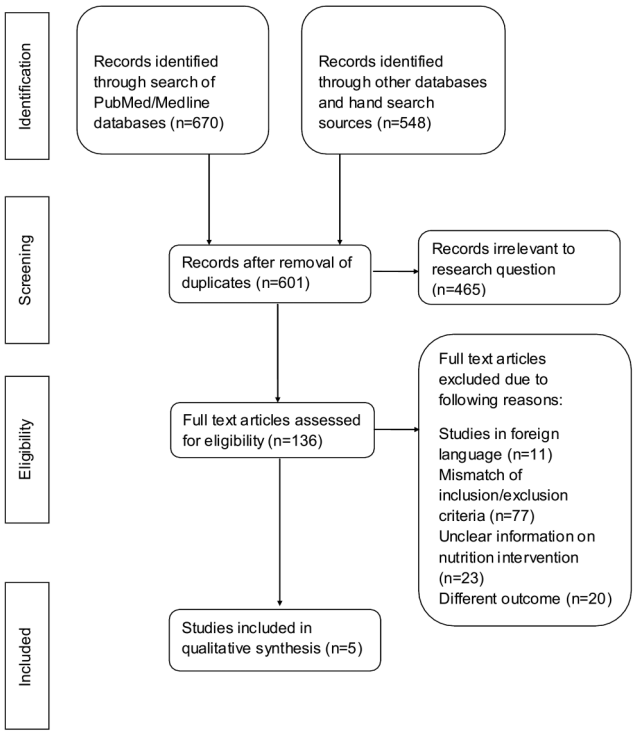

Figure 1 Flow diagram of process of selection of studies.

Sri Lanka was conducted in the Jaffna District after the tsunami of 2004.[30]

Interventions

In the study from China, complementary food supplementation known as Ying Yang Bao (in Chinese) was given. The ingredients of this supplement were as follows (nutrients/10 g/pack/day): protein 3.0 g from soybean; vitamin A 250 mg; vitamin D3 200 IU (5 mg); vitamin B1 0.3 mg; vitamin B2 0.3 mg; iron 5 mg; zinc 5 mg; calcium 250 mg. One pack of Ying Yang Bao contained 40 kcal energy, 2.0 g fat and 2.5 g carbohydrates.[31] The intervention lasted for one and a half years. There was a significant reduction in the prevalence of wasting, stunting, underweight and anaemia 18 months after the nutritional intervention.

A phased nutritional intervention was carried out in the study from Sri Lanka. During phase I, children between 6 and 59 months of age were given formula 75 (F75) during the stabilisation phase followed by formula 100 (F100), alternating with ready-to-use therapeutic food (RUTF) during the transition phase when there was a return of appetite and reduced or minimal oedema. Children without complications were given take-home rations of BP-100 as RUTF. Children below 1 year of age were given BP-100 as porridge dissolved in boiled, cool drinking water, and those above 1 year were given BP-100 as biscuits with an appropriate quantity of water. During phase II of implementation, children with SAM and moderate acute malnutrition were given high-energy biscuits during screening which was followed by supplementation with Plumpy'Nut as RUTF. During the maintenance phase, corn/soya blend or Thriposha supplementary feeding was provided to underweight children and children with growth faltering.[30] The intervention also included phased implementation of different activities such as capacity building, raising community awareness, community screening, case finding and monitoring. The intervention lasted for 13 months. There was a reduction in the prevalence of wasting, stunting and underweight compared with baseline but the statistical significance was not reported.

The study from Bangladesh used micronutrient powder as a food supplement. This powder was branded as Mix Me and locally branded as Pushtika. One dose comprised 1 g powder which contained one recommended nutrient intake each of the vitamins and minerals contained.[32] The period of intervention was 6 months. In the intervention group, there was a lower prevalence of stunting among those who consumed at least 75% of the micronutrient powder sachet compared with those who consumed <75% of the sachet.

In the study from India, Nutritional Care Centres (NCCs) were set up in different villages. Services provided in the NCCs included growth monitoring and promotion, targeted feeding (three times at NCCs and two times by paying home visits), use of oral rehydration solution, immunisation, vitamin A supplementation, nutrition and health education focusing on exclusive breast feeding up to 6 months of age, complimentary feeding after 6 months of age, feeding care during illness, use of iodised salt, and immunisation.[33] The intervention lasted for 6 months. There was a reduction in the prevalence of underweight children compared with baseline.

A blanket supplementary feeding programme was carried out in the study from Kenya which included monthly rations of corn/soya blend plus and oil in two counties. Interventions such as vitamin A supplementation, deworming, immunisation as per the national protocol, and health education were also included in the blanket supplementary feeding programme.[29] The intervention lasted for 7 months. The weight-for-height Z score significantly improved in both the counties.

Study design of included studies

None of the included studies were RCTs or quasi-experimental studies. Four of the studies had a longitudinal design.[29–31 33] One study was a cross-sectional survey with a comparison group.[32] The study from Kenya included two cohorts of children belonging to different counties. However, neither cohort had a control group (table 1).

Sampling methods

Three of the included studies used probability proportional to size methods (Sri Lanka, China and Kenya). The remaining studies used stratified random sampling (India) and multistage random sampling (Bangladesh).

Duration of the intervention

The duration of different types of nutritional interventions of the included studies ranged from 6 months to 13 months.

Effect of the intervention

Dong *et al*[31] found a statistically significant improvement in the length-for-age Z score, weight-for-age Z score and weight-for-length Z score after the introduction of complementary food supplements. The percentages of wasting, stunting and underweight had declined from 3.5%, 8.9% and 4.5% to 1.7%, 5% and 3.3%, respectively. The average haemoglobin level had also increased significantly in each age group. The effect of the intervention was measured at 6, 12 and 18 months. Jayatissa *et al*[30] found that the prevalence of wasting, stunting and underweight had improved from 18%, 18.2% and 30.8% to 9.6%, 15.2% and 14.4%, respectively. Global acute malnutrition (GAM) had declined from 18% to 9.6%, and the prevalence of SAM from 3.5% to 0.7%. The effect of the intervention was measured after 2 years. However, statistical significance was not reported. Rah *et al*[32] found that, among the children in the intervention area, those who had consumed at least 75% of the micronutrient sachets had significantly lower prevalence of stunting than those who had consumed <75%. The prevalence of anaemia did not differ between the intervention and control group even after multivariate analysis with adjustment for various factors. The effect of the intervention was measured after 1 month. Kumar and Bhawani[33] found a reduction in the proportion of severely underweight children (weight-for-age Z score 3SD below median) from 32.9% to 26.1%. The overall child undernutrition (weight-for-age Z score 2SD below median) had decreased from 66.7% to 59.6% 1 month after the intervention. Statistical significance was not reported in this study. In the study from Kenya, there was a statistically significant improvement in weight-for-height Z score in both Turkana and Wajir counties. The effect of the intervention was measured five times over the period of 8 months.[29]

Quality of the evidence

Overall, the quality of the studies ranged from moderate to weak. Only five studies matched our inclusion criteria for the review. None of the studies had similar nutritional outcomes. None of the included studies were RCTs. Although four of the studies were longitudinal by design, none had included a control group, which weakened the study design, thereby downgrading the quality. A comparison group was present in the study from Bangladesh. However, the study design was cross-sectional.[32] Lack of temporal association in cross-sectional studies is a major limitation. Regarding statistical analysis, only two studies applied multivariate analysis to explore the association of various confounding variables with nutritional outcomes.

Among the included studies in this review, we found a high risk of bias for all the domains in the study by Jayatissa *et al*.[30] Studies that used statistical calculation of sample size and random sampling techniques had a low risk of bias in terms of selection of participants and confounding variables.[29 32] In the domains of blinding of outcome assessment, incomplete outcome data, and selective outcome reporting, we found a high risk of bias in all the included studies (table 2).

DISCUSSION

This review shows limited evidence on the effectiveness of nutrition interventions following natural disasters. However, three of the included studies offer a moderate level of evidence on improved nutrition status of children aged 6–59 months following nutrition interventions. The most consistent outcome in all the five included studies was prevalence of wasting. Four studies reported a reduced prevalence of wasting, followed by a reduced prevalence of underweight in four, stunting in three and anaemia in one of the five included studies.

Weight for height is the preferred nutritional index in emergency contexts, as it reflects recent nutritional status and wasting. It is also the most used indicator to gauge the severity of an emergency and plan for adequate response.[5] This review showed a reduction in the prevalence of wasting following nutritional intervention in four of the included studies. Wasting was consistently reduced after the majority of interventions. Wasting is a strong predictor of mortality among children under five and could be a result of significant

Table 2 Risk of bias assessment of non-randomised studies (RoBANS)

	Domains					
Authors	Selection of participants	Confounding variables	Intervention (exposure) measurement	Blinding of outcome assessment	Incomplete outcome data	Selective outcome reporting
Dong *et al*[31]	B	C	C	C	C	C
Jayatissa *et al*[30]	C	C	C	C	C	C
Rah *et al*[32]	A	A	B	C	C	C
Kumar and Bhawani[33]	A	C	C	C	C	C
CDC US[29]	A	A	C	C	C	C

A, low risk of bias; B, unclear risk of bias; C, high risk of bias.

acute food shortage.[2] The largest reduction in prevalence of wasting occurred in Sri Lanka where the intervention was a nutritional rehabilitation programme. It included phased implementation of different activities such as capacity building, raising community awareness, community screening, case finding and monitoring, in addition to therapeutic food supplementation. This programme was integrated into the routine healthcare system covering the entire affected district of Sri Lanka. A similar approach was undertaken in the study from India, where the local community was mobilised to set up NCCs, which provided a range of services, such as growth monitoring and promotion, targeted feeding, immunisation, vitamin A administration and health education. Wasting was not assessed as an outcome in the study from India so we could not compare the effectiveness of these studies.

Underweight was another common nutritional outcome indicator measured in four of the included studies conducted in Sri Lanka, India, China and Bangladesh. The largest reduction in prevalence of underweight was also observed in the study from Sri Lanka followed by India and China. As weight is easy to measure, underweight is the indicator for which most data have been collected in the past.[34]

Stunting was a common outcome in studies conducted in China, Sri Lanka and Bangladesh. There was a greater reduction in the prevalence of stunting in the study from China (43.8%) compared with Sri Lanka (16.5%). Stunting is a consequence of failure to receive adequate nutrition for an extended period. Change in the prevalence of stunting depends on many other proximal factors apart from complementary feeding.[31 35] Quality and quantity of complementary food, dietary quality, changes in breast milk intake after introduction of complementary food, and associated morbidities are some of the proximal factors. These factors can affect the linear growth of children and need to be addressed by any complementary food intervention.[35] So the exact reason for the difference in the reduction of the prevalence of stunting is unknown, but these proximal factors may have led to the observed difference.

GAM and SAM are used to assess the severity of nutritional crises. A weight-for-height Z score of < −3 or nutritional oedema is categorised as SAM, whereas a weight-for-height Z score of −2 and nutritional oedema is categorised as GAM. Their inclusion in nutritional intervention studies will help to assess effectiveness better.[36 37] However, these indicators were calculated in the study from Sri Lanka only, which found a large reduction in the prevalence of GAM and SAM after nutritional intervention. The use of similar outcomes in the other studies would have helped us to compare the effectiveness of nutritional interventions.

Three of the included studies had tested anaemia in the affected children. Only one study from China had assessed anaemia before and after the nutritional intervention and found a significant decrease from 74.3% to 37.4% after 6 months. The study from Sri Lanka had assessed haemoglobin level at the end of the survey only and found the prevalence of anaemia to be higher than the national level (34% vs 25%) in spite of the provision of iron-rich supplementary food. Such a high prevalence of anaemia may have been due to the high phytate content of the typical diet of residents of Jaffna District in Sri Lanka.[30] Other factors could be iron bioavailability of the population and iron content of the supplemented food. Although the nutritional intervention in the study from Sri Lanka was more comprehensive, there was no baseline assessment of anaemia, which resulted in the lack of knowledge on decrease in anaemia prevalence.

Certain limitations need to be considered to interpret the findings of this review. First, the literature in this area is limited and so we cannot obtain strong evidence. We found no RCTs, cluster RCTs or quasi-experimental studies on nutritional interventions for under-five children following natural disasters. A major reason may be the difficulty in implementing RCTs in such settings because of ethical issues. There was heterogeneity in the design and nutritional outcome indicators calculated by the included studies. Also most of the included studies lacked a proper comparison group. Therefore, the evidence on which type of nutrition intervention is most effective in such a setting is still lacking. Given the context of increasing numbers of natural disasters in recent years, the lack of enough evidence highlights the need for more quality intervention studies in this area.

Second, the selected studies came from different regions and there is a risk of regional variability. This can result from a difference in the nature of the participants as well as service providers.[38] Also, the improvement in the nutritional status of children cannot be attributed to the interventions alone. The recovery process undertaken by the disaster-affected people themselves is an important confounder. Other interventions, such as healthcare, water, sanitation, hygiene and livelihood, were also scaled up during the time of crisis which could have affected the nutritional status.[29]

Third, reporting bias is a major limitation in our review, as only those studies with positive outcomes of interventions are likely to be published. Silent emergencies are less likely to be reported because of relative lack of data.[5] Last, studies published in languages other than English were not included in this review, which may have limited the review of important findings published in other languages.

Despite these limitations, this study shows that nutrition interventions in post-disaster settings are achievable and have the potential to improve the nutritional outcomes of vulnerable age groups. The study also suggests that interventions that are integrated with community mobilisation and health promotion activities may be more sustainable in the long run. This may be particularly applicable in resource-poor settings, where the prevalence of nutrition deprivation is high even in normal circumstances.

We recommend that future studies conducted in the background of natural disasters should adopt common nutritional outcome indicators (eg, wasting) for ease of comparison. Also, the inclusion of a control group in such studies is important, rather than comparing with baseline values, as the natural course of recovery in affected communities cannot be differentiated without a control group.

CONCLUSIONS

A natural disaster is a critical period to address the nutritional challenges in under-five children. Integrated nutrition interventions using locally available health resources may yield the best results. However, sound evidence on the most effective interventions is still lacking. Although conducting RCTs during times of immediate crisis may be difficult, intervention studies from such settings may help in better planning and preparedness for future events. Further intervention studies with comparison groups are necessary to assess the effectiveness of nutrition interventions.

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Contributors RD conceptualised the research, designed the study, participated in the literature review and analyses, and provided critical appraisal. PMSP helped conceptualise the research, designed the study, participated in the literature review and analyses, wrote the first draft of the manuscript, provided critical appraisal, and revised the subsequent versions. HS helped design the study, participated in the literature review and analyses, and revised the final version of the manuscript. All the authors read and approved the final version of the manuscript for submission.

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