

Table 2 | Risk of bias assessment cluster RCTs Cluster RCTs.

	Selection bias: allocation con- cealment	Performance bias: blinding of participants and personnel	Detection bias: blinding of outcome assessment	Attrition bias: incomplete outcome data	Reporting bias: selective reporting
Zaman et al. (22)	+	+	+	+	+
Bassichetto and Réa (13)	+	+	+	+	+
Moore et al. (14)	+	+	+	+	+
Pelto et al. (19)	+	+	+	?	+
Santos et al. (15)	+	+	+	+	+
Penny et al. (23)	+	?	+	+	+

+ Indicates low risk of bias, – indicates high risk of bias, and ? indicate unclear risk of bias.

Table 3 | Risk of Bias (ROB) and methodological quality for non-randomized studies.

Author	Reporting (10)	External validity (3)	Internal validity-bias (7)	Internal validity-(confounding) selection bias (6)	Power (1)
Palermo et al. (37)	8	3	6	4	No
Lindorff-Larsen et al. (17)	8	3	6	4	No
Puoane et al. (38)	5	2	4	2	No
Hamer et al. (39)	8	1	6	3	Yes
Edwards and Wyles (40)	6	2	5	1	Yes
O'Mahony et al. (41)	8	2	6	4	No
Hillenbrand and Larsen (20)	9	2	6	4	No
Olsson et al. (42)	8	3	6	4	Yes
Pedersen et al. (43)	9	2	6	4	No
Gance-Cleverland et al. (21)	8	3	4	4	No
Bjerrum et al. (18)	5	2	4	2	No
Kennelly et al. (45)	9	3	6	4	Yes
Kennelly et al. (44)	9	3	6	4	Yes
Simoes et al. (46)	9	2	5	4	No
Davies-Adetugbo and Adebawa (47)	9	3	6	4	Yes
Newes-Adeyi et al. (48)	8	2	6	4	No
Stark et al. (49)	9	3	7	2	Yes
Charlton et al. (24)	9	3	6	4	Yes

(MUST) (41, 44, 45), and nutrition training prepared specifically to suit the specific situation or context. Across training types, the lowest training duration was 4 h (21), while the longest training duration was 6 weeks of online training (49).

The main outcome of interest from the selected studies are presented in **Table 4** according to our objectives. Health workers' nutrition knowledge after the nutrition training intervention was reported in a total of 18 studies: 3 RCTs (13–15), 1 controlled non-randomized trial (16), and 14 pre–post-intervention studies (17, 18, 20, 21, 37, 39–42, 44, 46, 47). Counseling and communication skills of health workers who underwent the nutrition intervention were reported in 12 studies: 6 RCTs (13–15, 19, 22, 23) and 6 pre–post-intervention studies (20, 21, 44–46, 48). A total of 16 studies

reported health workers' management skills for child undernutrition after undergoing nutrition training. Among such studies, 3 were RCTs (13, 15, 22), 1 was a controlled non-randomized trial (16), and 14 were pre–post-intervention evaluation studies (24, 37–46, 49).

EFFECTIVENESS OF THE INTERVENTION TO IMPROVE HEALTH WORKERS' NUTRITION KNOWLEDGE (A NARRATIVE SUMMARY)

Table 5 summarizes the 18 reviewed studies that included nutrition knowledge as the outcome variable. Among these studies, three used a cluster RCT design and were conducted in Brazil (13, 15) and the UK (14). A higher proportion of doctors who received the nutrition training intervention in the Brazilian studies had

Table 4 | General description of studies included in the review.

Author	Study design	Nutrition training intervention	Outcome of interest
Zaman et al. (22), Pakistan	Cluster RCT	Nutrition-counseling training using IMCI's "counsel the mother" module for five and a half days. It included infant feeding knowledge and practice sessions for the development of communication and counseling skills	Communication skills Nutrition counseling Nutrition management/practice
Bassichetto and Réa (13), Brazil	Cluster RCT	WHO's "infant and young child feeding counseling: an integrated course." The training includes 8 h of practical sessions. Out of 34 sessions, 8 were dedicated to breastfeeding, 6 to HIV and infant and young child feeding, 7 to complementary feeding, 10 to counseling, and 4 to general themes, making a total of 40 h	Nutrition knowledge Nutrition counseling Undernutrition management/performance
Moore et al. (14), UK	Cluster RCT	A nutrition training program was delivered to six intervention practices (health facilities). Emphasis of the training was on increasing motivation to improve quality of dietary consultations and providing them with practical skills adapted from behavior models. Included components in the 7.5-h training were patients' assessment, education, and goal setting in issues of public health importance including drinking	Nutrition knowledge Counseling
Pelto et al. (19), Brazil	Cluster RCT	Physicians from the intervention group received a 20-h training in a program derived from the IMCI nutrition-counseling module. After training, they provided care to caregiver/child pairs who attended their centers	Counseling Practice: communication skills
Santos et al. (15), Brazil	Cluster RCT	Fourteen doctors received a 20-h nutrition-counseling training using IMCI's "counsel the mother" and "management of the sick young infant" modules. Based on local adaptation of IMCI feeding guidelines, the key feeding recommendations identified were as follows: increase breast and complementary feeding frequency, provide animal protein and micronutrient-rich foods, add oil to the food, and increase dietary diversity. Of the 20 h of training, 40% was used for practical sessions in a health center	Nutrition knowledge Nutrition counseling: undernutrition management skills/practice
Penny et al. (23), Peru	Cluster RCT	Interventions aimed to raise the nutrition profile of the health facility and to integrate nutrition services into existing child health programs through training and provision of simple messages to caregivers. Training included demonstration of preparation of complementary foods and child's age-specific group sessions for their caregivers. The intervention also included training for health care workers to improve anthropometry skills. An accreditation system was also introduced for institutional change	Nutrition counseling Others: health seeking behavior
Cattaneo and Buzzetti (16), Italy	Controlled non-randomized trial	An 18-h UNICEF "Breastfeeding, management, and health proportion in baby-friendly hospitals" course along with a 2-h counseling session from the WHO's breast-feeding counseling course were implemented	Nutrition knowledge Hospital performance
Palermo et al. (37), Australia	Pre-post-intervention study	Thirty-two dietitians were allocated to three intervention groups: two face-to-face groups and one rural video-linked group. The intervention involved a mentoring circle of experienced nutritionists and community-based dietitians. Each participant attended six 2-h sessions every 6 weeks for a 7-month intervention period	Nutrition knowledge and competence
Lindorff-Larsen et al. (17), Denmark	Pre-post-intervention study	A follow-up study was conducted in 2004 and compared to a baseline study in 1997. Nutrition training and use of nutrition guidelines were being introduced and used between the two study intervals. Details of such training were not further elaborated	Nutrition knowledge
Puoane et al. (38), South Africa	Pre-post-intervention study (with a qualitative design)	A 5-day course developed by the University of West Cape involved practice sessions, group work, role-plays, action plan development, key messages, and question and answer sessions. The course followed the principle of care set out by WHO for managing severe malnutrition. A total of 66 nurses from 11 referral hospitals underwent this course	Health workers' practice Attitudes

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Table 4 | Continued

Author	Study design	Nutrition training intervention	Outcome of interest
Hamer et al. (39), Gambia	Pre–post- intervention study	Nutrition training for nurses was conducted using the IMCI training manual, “assess and classify sick children aged 2 months to 5 years.” Training materials were provided to nurses a week prior to training. The training included both theoretical and practical components toward assessing children with and without wasting and/or edema admitted to the hospital	Nutrition knowledge Undernutrition management/practice
Edwards and Wyles (40), UK	Pre–post- intervention study	A total of 24 1-h training sessions were held, reaching 189 staff. Each session consisted of factual information, a brainstorming session about what a pregnant woman eat, and a nutrition game involving calculation of daily requirement for folic acid	Nutrition knowledge Health workers’ practice
O’Mahony et al. (41), UK	Pre–post- intervention study	Nutrition training was delivered to nurse participants. It also included the use of the Malnutrition Universal Screening Tool (MUST)	Nutrition knowledge Health workers’ practice
Hillenbrand and Larsen (20), US	Pre–post- intervention study	Forty-nine pediatric residents participated in a four-part education series about breastfeeding delivered over four consecutive days. The education intervention was internally designed using additional inputs from lactation experts and fellow pediatricians. The training included lectures, discussions, role-playing, and group exercises	Nutrition knowledge Nutrition counseling Counseling and practice
Olsson et al. (42), Sweden	Pre–post- intervention study	Nutrition education for nurses was conducted for 3 months. It was based on the use of nutrition assessments including energy intake, clinical complications of inadequate energy intake, hospital food energy content, patients energy requirements, weighing patients and its necessity, reasons for weight loss during illness, and fluid management	Nutrition knowledge Health workers’ practice
Pedersen et al. (43), Denmark	Pre–post- intervention study	Nutrition training was conducted for nurses. It included five modules of 3–4 days duration using the theory of planned change. The training incorporated basic nutrition education elements such as risk assessment, consequences of malnutrition, and assessment of needs and responsibility	Health workers’ practice
Gance-Cleveland et al. (21), US	Pre–post- intervention study	Thirty-five nurse practitioners received an intensive 4-h Healthy Eating and Activity Together Clinical Practice Guideline (HEAT CPG) training session	Nutrition knowledge Nutrition counseling
Bjerrum et al. (18), Denmark	Pre–post- intervention study	Sixteen nurses participated in a special training program on nutrition. It was based on experimental theories and included five modules spanning 3–4 days, combining theories of planned change and nutrition issues	Nutrition knowledge
Kennelly et al. (45), Ireland	Pre–post- intervention study	Seven general practitioners participated in the nutrition education program. A community dietician used a standardized presentation to conduct the program. The content of training included information on causes of malnutrition, effects of malnutrition, use of the MUST tool, practical dietary advice for patients with poor appetite, and evidence supporting the use of oral nutrition supplements (ONS)	Nutrition counseling Health workers’ practice
Kennelly et al. (44), Ireland	Pre–post- intervention study	An educational program incorporating the MUST training was implemented in 8 of 10 eligible primary practices, 7 private nursing homes, and 2 health centers. The training program was designed based on consultations with health professional groups, clinical guidelines from expert bodies, and current evidence for ONS use in community settings	Nutrition knowledge Nutrition counseling
Simoes et al. (46), Ethiopia	Pre–post- intervention study	A 9-day course using the pre-tested version of the IMCI course was provided to six clinic nurses. The training modules included assessment and classification of the sick child, treatment of the child, counseling the mother, and follow-up. Other modules included practical sessions in the clinic	Nutrition knowledge Nutrition counseling Health workers’ practice

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Table 4 | Continued

Author	Study design	Nutrition training intervention	Outcome of interest
Davies-Adetugbo and Adebawa (47), Nigeria	Pre–post-intervention study	A 1-day community mobilization with 6 h of training on breastfeeding and child survival was conducted for health workers and mothers. The training was designed to include the importance of breast-feeding, exclusive breastfeeding, lactation maintenance, expressed breast milk, practical demonstration of attachment, suckling, expression of milk, and cup feeding. An intensive 2-day training was then conducted for health workers using a WHO/UNICEF 18-h breastfeeding course manual. Training included practical, role-playing, and theory sessions	Nutrition and breastfeeding knowledge
Newes-Adeyi et al. (48), US	Pre–post-intervention study	A total of 35 women, infants, and children (WIC) staff underwent a 1-day intensive training program to improve their growth monitoring counseling and management of nutrition-related problems. The training included lectures, case studies, discussions, small group work, and role-plays	Nutrition counseling
Stark et al. (49), US	Quasi-experimental design	A 6-week online professional development program for nutrition and health practitioners course was delivered to the intervention group. It was based on the PRECEDE-PROCEED health program planning framework involving assessment of underlying factors for a health problem and strategizing the intervention	Nutrition knowledge and skills
Charlton et al. (24), Zambia	Pre–post-intervention study	Eight out of 16 health care workers received the Growth Monitoring and Promotion (GMP) training. Details of the training including duration and contents were not described	Nutrition knowledge Nutrition practice

high post-training nutrition knowledge compared to doctors in the control group. In the UK-based RCT among GPs, nutrition training did not significantly change health workers' nutrition knowledge (14). However, GPs in the intervention group were 30% more likely to believe that their nutrition knowledge was up-to-date compared to their counterparts in the control group ($P = 0.001$).

In an Italian controlled non-randomized trial with a comparison group (16), the mean nutrition knowledge score of nurses, midwives, and doctors increased from 0.41 to 0.72 in Group 1 and from 0.53 to 0.75 in Group 2 after the nutrition training. Compared to the delayed intervention control group, health workers in the intervention group registered a significant change in knowledge and skills ($P < 0.01$) in a quasi-experimental study conducted in the US.

Fourteen studies were conducted using a pre–post-intervention design in Australia (37), Denmark (17, 18), Gambia (39), UK (41), US (20, 21, 49), Sweden (42), Ireland (44), Ethiopia (46), Nigeria (47), and Zambia (24). In all of these studies, health workers' nutrition knowledge increased after nutrition training.

EFFECTIVENESS OF INTERVENTION TO IMPROVE NUTRITION-COUNSELING SKILLS OF HEALTH WORKERS (A NARRATIVE SUMMARY)

Table 6 shows the result of the 12 reviewed studies with nutrition counseling as an outcome variable following nutrition training of health workers. Of these studies, six were cluster RCTs and three were conducted in Brazil among doctors and pediatricians (13, 15, 19). Across all three studies, a significantly higher proportion of doctors in the intervention group had better post-training counseling skills and performed more nutrition

counseling compared to the respective control group. Physicians undergoing the training intervention also showed higher mean communication skill scores compared to untrained physicians ($P < 0.01$) (19). In a Pakistani cluster RCT among lady health visitors (LHVs) working at a health facility as mid-level providers, 82% of participants in the intervention group registered improved post-training communication skills compared to 51% in the control group ($P = 0.015$). In this study, a higher proportion of trained LHVs reported increased counseling skills compared to their counterparts. GPs with nutrition training in the UK study (14), meanwhile, were 30% more likely to provide dietary advice that was completely appropriate ($P = 0.01$). In Peru (23), twice as many mothers in the intervention group received post-partum nutrition advice compared to their control group counterparts following the nutrition training intervention for their health workers ($P = 0.02$).

A total of six studies using pre–post-intervention evaluation of nutrition training of health workers reported nutrition-counseling skills as an outcome variable. These studies were conducted in the US (20, 21, 48), Ireland (44, 45), and Ethiopia (46). In all six studies, nutrition and general counseling skills of health workers improved after nutrition training.

EFFECTIVENESS OF INTERVENTION TO IMPROVE HEALTH WORKERS' MANAGEMENT PRACTICES FOR CHILD UNDERNUTRITION (A NARRATIVE SUMMARY)

Table 7 summarizes the results of the 16 reviewed studies reporting management of undernutrition and management practices as an outcome variables following the nutrition training intervention. Within these studies, two of the three cluster RCTs were conducted in Brazil among medical doctors, pediatricians, and

Table 5 | The effectiveness of nutrition training to improve nutrition knowledge of health care workers.

Author	Study design	Health cadre	Nutrition training intervention	Comparison	Outcome: nutrition knowledge
Bassichetto and Réa (13), Brazil	RCT: 31 professionals received intervention and 28 were the control	Pediatricians and nutritionists	WHO's "infant and young child feeding counseling: an integrated course." The training includes 8 h of practical sessions. Out of 34 sessions, 8 were dedicated to breastfeeding, 6 to HIV and infant and young child feeding, 7 to complementary feeding, 10 to counseling, and 4 to general themes	Doctors and nutritionists in control group did not receive the training intervention.	Proportion of knowledge increase was more among HCWs in IG [e.g., Breastfeeding – IG-79.3%, CG-37% ($P=0.004$); HIV and IYCF – IG-48.3%, CG-18.5% ($P=0.049$); Complementary feeding – IG-69.0%, CG-37.0% ($P=0.012$)]
Moore et al. (14), UK	Cluster RCT-paired cluster randomized trial with pre- and post-intervention assessment	12 General practitioners	A training program was delivered to six intervention practices. Emphasis was on increasing motivation to improve quality of dietary consultations and providing practical skills adapted from behavior models. A 7.5-h training included patients' assessment, education, and goal setting in issues of public health importance including drinking	Six control practices did not receive nutrition training	IG-trained practitioners were 30% (95% CI 12–50, $P=0.001$) more likely to believe that their knowledge was up-to-date than practitioners in IG. There was no statistical significance difference in actual knowledge between IG and CG
Santos et al. (15), Brazil	RCT of 28 government health centers	28 Medical doctors	A total of 14 doctors in the intervention group received a 20-h nutrition-counseling training and practice using IMCI's "counsel the mother" and "management of the sick young infant" modules. The key recommendations identified were as follows: increase breast and complementary feeding frequency, provide animal protein and micronutrient-rich foods, add oil to the food, and increase dietary diversity	14 Doctors recruited for CG did not receive training	Doctors from IG correctly answered 83% (95% CI 65–100) of 77 questions on practical situations in the IMCI guidelines compared to 68% (95% CI 48–88) in the CG ($P=0.02$)
Cattaneo and Buzzetti (16), Italy	Controlled non-randomized study	Nurses, midwives, obstetricians, and physicians	An 18-h UNICEF "breastfeeding, management, and health proportion in baby-friendly hospitals" course along with a 2-h counseling session from the WHO breast-feeding counseling course were implemented	Post-training evaluation	In Group 1, nutrition knowledge went up from a mean score of 0.41 to 0.66 to 0.72. In Group 2, nutrition knowledge went from 0.53 to 0.53 to 0.75
Palermo et al. (37), Australia	Pre–post-intervention study	Nutritionists and dieticians	A total of 32 dieticians were allocated to three IGs: two face-to-face groups and one rural video-linked group. The intervention involved a mentoring circle of experienced nutritionists and community-based dieticians. Each participant attended six 2-h sessions every 6 weeks for a 7-month intervention period	Pre–post-intervention comparison (qualitative and quantitative)	Reported competency score increased post-training/mentoring. An increase in post-intervention measures was also reported: [69.1(13.8) to 79.3(12.1), $P < 0.001$]

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Table 5 | Continued

Author	Study design	Health cadre	Nutrition training intervention	Comparison	Outcome: nutrition knowledge
Lindorff-Larsen et al. (17), Denmark	Pre-post-intervention study	Doctors and nurses	A follow-up study was conducted in 2004 and compared to a baseline study in 1997. Nutrition training and guidelines were being introduced and used between the two study intervals. Details of such training were not further elaborated	A cross-sectional study, post-trainings and post-guideline application	About two-thirds of doctors and nurses expressed that their education nutrition was sufficient at post-intervention. Significantly fewer health workers lacked methods to identify undernutrition ($P < 0.001$) and difficult-to-identify patients in need of nutrition support ($P < 0.001$) at post-intervention
Hamer et al. (39), Gambia	Pre-post-intervention study	Registered nurses and auxiliary nurses	Nutrition training for nurses was conducted using the IMCI training manual, "assess and classify sick children aged 2 months to 5 years." It included both theoretical and practical components of assessing children with and without wasting and edema	Post-training evaluation	Nurses showed good knowledge and performance after the completion of training
Edwards and Wyles (40), UK	Pre-post-intervention study	Midwives, physicians, dieticians, and nurses	A total of 24 1-h training sessions were held for 189 staff. Each session consisted of factual and brainstorming sessions about what a pregnant woman eats, and a nutrition calculation of daily requirement for folic acid	Post-training evaluation	Health workers' nutrition knowledge improved post-training
O'Mahony et al. (41), UK	Pre-post-intervention study	Nursing staff	Nutrition training was delivered to nurse participants on the use of the Malnutrition Universal Screening Tool (MUST)	Post-training evaluation	A non-significant difference in post-training nutrition knowledge was observed [Mean (SD) knowledge score 21(6.7) vs. 23(6.2)]. A significant difference was observed in sub-analyses by bands. Nurses were more aware that malnutrition was a significant problem for the National Health Service post-training ($P < 0.027$)
Hillenbrand and Larsen (20), US	Pre-post-intervention study	Pediatric residents	A total of 49 pediatric residents participated in a four-part education series about breastfeeding over 4 consecutive days. It included lectures, discussions, role-playing, and group exercises. The education intervention was internally designed by the authors using inputs from lactation experts and fellow pediatricians	Post-training evaluation	Mean composite knowledge score was 80% post intervention compared to 69% pre-intervention, representing an 11% increase ($P < 0.01$)

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Table 5 | Continued

Author	Study design	Health cadre	Nutrition training intervention	Comparison	Outcome: nutrition knowledge
Olsson et al. (42), Sweden	Pre–post-intervention study	Nurses	Nutrition education for nurses was conducted for 3 months. It was based on the use of nutrition assessment including energy intake, clinical complications of inadequate energy intake, hospital food energy, patients' energy requirements, weighing patients and its necessity, reasons for weight loss during illness, and fluid management	Post-training evaluation	69% Of nurses could calculate a patient's energy requirement post-training compared to 24% pre-training ($P < 0.01$). Compared to pre-training, more nurses knew the energy content of hospital food (61 vs. 45%, $P < 0.05$), knew how to handle enteral infusion equipment (55 vs. 6%, $P < 0.01$), and found it easy to assess patients' energy needs (56 vs. 24%, $P < 0.01$)
Gance-Cleverland et al. (21), US	Pre–post-intervention study	Nurse practitioners	A total of 35 nurse practitioners received an intensive 4-h Healthy Eating and Activity Together Clinical Practice Guideline (HEAT CPG) training session	Post-training evaluation	Nutrition knowledge post training improved, including on assessment of growth ($P < 0.001$), assessment of family history ($P < 0.001$), and assessment of physical activity ($P < 0.001$). Practitioners' nutrition recommendation knowledge also improved post-training compared to pre-training
Bjerrum et al. (18), Denmark	Pre–post-intervention study	Nurses	A total of 16 nurses participated in a special training program on nutrition. It was based on experimental theories. A total of five modules lasting 3–4 days were included. They combined theories of planned change and nutrition issues	Post-training evaluation	A short-duration training program enhanced nurses' awareness of nutrition care, management through assessment and monitoring, their management roles, and approach to clinical nutrition
Kennelly et al. (44), Ireland	Pre–post-intervention study	General practitioners (GPs) and nurse practitioners	An educational program incorporating Malnutrition Universal Screening Tool (MUST) training was implemented in 8 of 10 eligible primary practices, seven private nursing homes, and two health centers. The training program was designed based on consultations with health professional groups, clinical guidelines from expert bodies, and current evidence for oral nutrition supplementation (ONS) use in community settings	Post-training evaluation	Nutrition knowledge improved across three evaluation points ($P < 0.05$). For specific groups, a significant improvement in knowledge score was also observed among general practitioners ($P < 0.001$) and nurses ($P < 0.001$)
Simoes et al. (46), Ethiopia	Pre–post-intervention study	Clinic nurses	Six clinic nurses received a 9-day course using the pre-tested version of the IMCI course. The training modules included assessment and classification of a sick child, treatment of the child, counseling the mother, and follow-up. Other modules included practical sessions in the clinic	Post-training evaluation	After training, nurses could recognize visible severe wasting with a 67% sensitivity and 99% specificity; conjunctiva pallor for anemia at 45% sensitivity and 94% specificity; and bipedal edema with 69% sensitivity and 98% specificity

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Table 5 | Continued

Author	Study design	Health cadre	Nutrition training intervention	Comparison	Outcome: nutrition knowledge
Davies-Adetugbo and Adebawa (47), Nigeria	Pre-post-intervention study	Community health extension workers	A 6-h training on breastfeeding and child survival was conducted for health workers and mothers. The training included the importance of breast-feeding, exclusive breastfeeding, lactation maintenance, expressed breast milk, practical demonstration of attachment, suckling, expression of milk, and cup feeding. An intensive 2-day training was then conducted for health workers using a WHO/UNICEF 18-h breastfeeding course manual. Training included practical, role-playing, and theory sessions	Post-training evaluation	Trained health workers had a significantly higher aggregate knowledge score compared to their untrained counterparts [9.4(9.1–9.7) vs. 7.6(6.6–8.6), $P < 0.001$]
Stark et al. (49), US	Quasi-experimental design using intervention and delayed intervention comparison group	Nutrition and health professionals	An online professional development program for nutrition and health practitioners course was given to the intervention group for 6 weeks. It was based on the PRECEDE-PROCEED health program planning framework involving assessment of underlying factors for a health problem and strategizing the intervention	Delayed intervention control group	Compared to the control group, the intervention group reported significant positive changes ($P < 0.01$) on knowledge and skills scores
Charlton et al. (24), Zambia	Pre-post-intervention study	Health workers for growth monitoring and promotion	Eight out of 16 HCWs received the growth monitoring and promotion training	Post-training evaluation	Compared to untrained HCWs, trained HCWs could correctly define growth monitoring and promotion ($P < 0.001$)

IG, intervention group; CG, control group; HCWs, health care workers.

nutritionists (13, 15). Doctors in the intervention group were more likely to report improved post-intervention practices in managing child undernutrition compared to their counterparts. In the Pakistani study, trained LHV's were more likely to plot children's weights, discuss appropriate foods with caregivers, and check mothers' understanding of imparted nutrition knowledge compared to their counterparts in the control group. In an Italian controlled non-randomized trial (16), all hospitals improved their compliance with WHO's "Ten Steps to Successful Breastfeeding" after undergoing the WHO baby-friendly hospital and counseling course.

Nutrition and health professionals in the quasi-experimental design study in the US exhibited better nutrition management skills after the 6-week online nutrition training (49). Compared to health workers in the delayed intervention control group, those in the intervention group registered significant positive changes on knowledge and skills scores ($P < 0.01$).

Eleven pre-post-intervention studies on nutrition training of health workers were conducted in Australia (37), South Africa

(38), Gambia (39), UK (40, 41), Sweden (42), Denmark (43), Ireland (44, 45), Ethiopia (46), US, and Zambia (24). In all these studies, management practices and competence of health workers improved after the intervention compared to pre-nutrition training intervention levels.

DISCUSSION

This is the first systematic review to examine the effectiveness of in-service nutrition training to improve health workers' nutrition knowledge, nutrition counseling, and undernutrition management practices. In this review, we reviewed a total of 25 studies reporting on nutrition training interventions. Across all three of our outcome variables, significant post-intervention improvements were reported. First, in-service nutrition training improved health workers' nutrition knowledge. Second, the counseling skills and competence of health workers were also improved after in-service nutrition training. Third, the training intervention improved child undernutrition management practices of participating health workers.

Table 6 | Effectiveness of nutrition training to improve nutrition counseling and counseling skills of caregivers.

Author	Study design	Health cadre	Intervention	Comparison	Outcome: nutrition counseling
Zaman et al. (22), Pakistan	Cluster RCT: 18 health centers were assigned to IG and a similar number to CG	Lady health visitors (MLVs)	Nutrition-counseling training using IMCI's "counsel the mother" module for five and a half days. It included infant feeding knowledge and practice sessions to develop communication and counseling skills	Health centers of the control group without counseling training for health workers	Counseling: asking about feeding practices and paying attention to answers: IG-50%, CG-25%, $P = 0.056$; praising mothers for positive action: IG-37%, CG-8%, $P = 0.006$. Appropriate recommendations to specific changes with explanation: IG-29%, CG-4%, $P = 0.01$ Communication skills: IG-82%, CG-51%, $P = 0.015$
Bassichetto and Réa (13), Brazil	RCT: 31 professionals received intervention and 28 were recruited as a control group	Pediatricians and nutritionists	WHO's "Infant and young child feeding counseling: an integrated course" was administered. The training includes 8 h of practical sessions. Out of 34 sessions, 8 were dedicated to breastfeeding, 6 to HIV and infant and young child feeding, 7 to complementary feeding, 10 to counseling, and 4 to general themes	Participants recruited for the control group did not receive the training intervention	Counseling: IG-51.7%, CG-22.2% ($P = 0.004$)
Moore et al. (14), UK	Cluster RCT-paired cluster randomized trial with pre- and post-intervention evaluation	General practitioners	A training program was delivered to six intervention practices. Emphasis was on increasing motivation to improve quality of dietary consultations and providing practical skills adapted from behavior models. A 7.5-h training included patients' assessment, education, and goal setting in issues of public health importance including drinking	A total of six control practices did not receive nutrition training	Counseling: trained practitioners were 30% (95% CI 7–53, $P = 0.01$) more likely to provide dietary advice that was completely appropriate
Pelto et al. (19), Brazil	Cluster RCT of 28 municipal health centers	Doctors	Physicians from the intervention group received a 20-h training in a program derived from the IMCI nutrition-counseling module. After training, they provided care to caregiver/child pairs attending their centers	Physicians in the control group received a clinical refresher course but not on nutrition counseling	Counseling: trained providers engaged more in nutrition counseling [only 9(24%) consultations of IG participants did not include advice compared to 14 (43%) among CG participants: $P < 0.013$]; gave 81 messages compared to 20 of untrained ones ($P < 0.002$); gave more message specific to foods, preparations, and feeding practices compared to untrained ones ($P < 0.01$) Communication skills: mean communication skills score of trained physicians was 3.94 (SD 1.68) vs. 1.38 (SD 1.02) for untrained ones ($P < 0.01$)

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Table 6 | Continued

Author	Study design	Health cadre	Intervention	Comparison	Outcome: nutrition counseling
Santos et al. (15), Brazil	RCT of 28 government health centers	28 Medical doctors	A total of 14 doctors of the IG received a 20-h nutrition-counseling training and practice using IMCI's "counsel the mother" and "management of the sick young infant" modules. The key recommendations identified were as follows: increase breast and complementary feeding frequency, give animal protein and micronutrient-rich foods, add oil to the food, and increase dietary diversity	14 doctors recruited for the control group did not receive the training	Counseling: 83% of mothers in IG compared to 49% of mothers in CG received nutrition counseling ($P < 0.001$)
Penny et al. (23), Peru	Cluster RCT of 12 health facilities serving periurban areas	Health workers in selected health facilities	The intervention included training for HCWs to improve anthropometry skills. An accreditation system was also introduced for institutional change. Also it included demonstration of preparation of complementary foods and child's age-specific group sessions for caregivers	HCWs and caregivers of CG did not receive the training intervention	Counseling: twice as many mothers in IG received nutrition advice after birth compared to those in CG (52 vs. 24%, $P = 0.02$). Greater impacts on counseling were observed at 4 and 18 months post-intervention ($P < 0.002$)
Hillenbrand and Larsen (20), US	Pre-post-intervention study	Pediatric residents	A total of 49 pediatric residents participated in a four-part education series about breastfeeding over four consecutive days. The training included lectures, discussions, role-playing, and group exercises. The education intervention was designed using additional inputs from lactation experts and fellow pediatricians	Post-training evaluation	Counseling: residents showed an increased knowledge in advising mothers concerning low milk supply ($P = 0.045$), infections including mastitis ($P = 0.002$), or abscess ($P < 0.001$) Counseling and practice: residents showed significant increases in counseling on signs of breast-feeding adequacy ($P = 0.012$) and managing lactation problems correctly ($P = 0.004$)
Gance-Cleveland et al. (21), US	Pre-post-intervention study	Nurse practitioners	A total of 35 nurse practitioners received an intensive 4-h Healthy Eating and Activity Together Clinical Practice Guideline (HEAT CPG) training session	Post-training evaluation	Counseling: participants reported a significant improvement in behavior modification techniques ($P < 0.001$) and practitioners' counseling ($P < 0.001$)
Kennelly et al. (45), Ireland	Pre-post-intervention study	General practitioners-doctors	Seven GPs participated in the nutrition education program. The content of training included causes of malnutrition, effects of malnutrition, the use of the Malnutrition Universal Screening Tool (MUST), practical dietary advice for patients with poor appetite, and evidence supporting the use of oral nutrition supplements (ONS)	Post-training evaluation	Counseling: basic dietary advice provided by a health professional increased significantly post-training (90 vs. 26%, $P < 0.001$)

(Continued)

Table 6 | Continued

Author	Study design	Health cadre	Intervention	Comparison	Outcome: nutrition counseling
Kennelly et al. (44), Ireland	Pre-post-intervention study	General practitioners (GP) and nurse practitioners	An educational program incorporating the MUST training was implemented in 8 of 10 eligible primary practices, seven private nursing homes, and two health centers. The training program was designed based on consultations with health professional groups, clinical guidelines from expert bodies, and current evidence for ONS use	Post-training evaluation	Counseling: about 80% of HCWs reported always providing nutrition advice to patients
Simoes et al. (46), Ethiopia	Pre-post-intervention study	Clinic nurses	A 9-day course using the pre-tested version of the IMCI course was provided to six clinic nurses. The training modules included assessment and classification of sick child, treatment of the child, counseling the mother, and follow-up. Other modules included practical sessions in the clinic	Post-training evaluation	Counseling: trained health workers provided feeding advice rated as "good" by 78%, "fair" at 18% and "poor" at 4%
Newes-Adeyi et al. (48), US	Pre-post-intervention study	Health workers of a special nutrition program	A total of 35 health workers underwent a 1-day intensive training program to improve their growth monitoring counseling and management of nutrition-related problems. The training included lectures, case studies, discussions, small group work, and role-plays	Post-training evaluation	Counseling: compared to pre-training, there was a significant change in elicitation ($P < 0.001$) and negotiation proficiency ($P = 0.07$). The level of engagement in discussing provider suggestions for follow-up strategies increased from 1.8 to 2.3 ($P < 0.01$) and the overall responsiveness level increased from a mean of 2.4–2.8 ($P < 0.07$)

IG, intervention group; CG, control group; HCWs, health care workers.

A total of 18 studies, including five with a cluster RCT design, showed significant post-nutrition training improvements in health workers' nutrition knowledge. These studies were conducted in areas of varying social and economic levels and geographic characteristics. Health workers might also have been exposed to nutrition education during their college training (8). However, previous studies have indicated that such training is inadequate or not in keeping with the clinical reality encountered in practice (9, 10). Lack of such knowledge might also cause them to refrain from providing nutrition counseling and care to their clients (8). Sometimes, due to lack of adequate nutrition knowledge, doctors feel that it is the duty of nurses or other cadres below them to provide nutrition counseling and care. To improve knowledge of such health workers, it is important to expose them to in-service nutrition training tailored to their environment, context, and health cadre (9). This will help to boost their competence

and confidence in management of nutrition-related conditions including undernutrition.

In this systematic review, a total of 12 studies, including six cluster RCTs, showed a significant improvement in counseling skills among health workers with in-service nutrition training. Nutrition training would thus seem to be effective in improving health workers' nutrition knowledge. Nutritionally informed health workers may be more confident to address nutrition-related conditions in their patients (51). Such health workers may be better equipped to provide appropriate advice and counseling to their clients. The prevailing attitude toward nutrition counseling among medical doctors and pediatricians that such functions are not within their job description might also change after nutrition training. In this way, such trained health workers would be more likely to provide nutrition counseling (52). In line with the health belief model, nutrition knowledge provided to the health workers

Table 7 | Effectiveness of nutrition training to improve nutrition management practices and competence of health workers.

Author	Study design	Health cadre	Intervention	Comparison	Outcome: nutrition management or practice
Zaman et al. (22), Pakistan	Cluster RCT: 18 health centers were assigned IG and a similar number were assigned to CG	Lady health visitors	Nutrition-counseling training using IMCI's "counsel the mother" module for five and a half days. It included infant feeding knowledge and practice sessions for development of communication and counseling skills	HCWs of the CG received no counseling training	Practice: HCWs in the intervention group were more likely to plot the weight of a child, discuss foods appropriate to the child, and check if mothers understood information provided
Bassichetto and Réa (13), Brazil	RCT: 31 professionals recruited to IG and 28 for CG	Pediatricians and nutritionists	WHO's "infant and young child feeding counseling: an integrated course" was implemented. The training includes 8 h of practical sessions. Out of 34 sessions, 8 were dedicated to breastfeeding, 6 to HIV and infant and young child feeding, 7 to complementary feeding, 10 to counseling, and 4 to general themes	HCWs in the CG did not receive the training intervention	Performance: IG participants improved their dietary anamnesis during consultations after intervention ($P < 0.001$)
Santos et al. (15), Brazil	RCT of 28 government health centers assigned to either IG or CG	28 Medical doctors	A total of 14 doctors of IG received a 20-h nutrition-counseling training and practice using IMCI's "counsel the mother" and "management of the sick young infant" modules. The key recommendations identified were as follows: increase breast and complementary feeding frequency, provide animal protein and micronutrient-rich foods, add oil to the food, and increase dietary diversity	Doctors in the CG did not receive counseling training	Practice: doctors from IG were more likely to assess child's complementary feeding, assess breast-feeding, use good communication skills, and use and provide mothers with a card compared to CG
Cattaneo and Buzzetti (16), Italy	Controlled non-randomized	Nurses, midwives, obstetricians, and physicians	An 18-h UNICEF "breastfeeding, management, and health proportion in baby-friendly hospitals" course along with a 2-h counseling session from the WHO breast-feeding counseling course was implemented	Post-training evaluation	Performance: all hospitals improved their compliance with the WHO 10 steps to successful breastfeeding
Palermo et al. (37), Australia	Pre-post-intervention study	Nutritionists and dieticians	A total of 32 dieticians were allocated to three intervention groups: two face-to-face groups and one rural video-linked group. The intervention involved a mentoring circle of experienced nutritionists and community-based dieticians. Each participant attended six 2-h sessions every 6 weeks for a 7-month intervention period	Pre-post-intervention comparison (qualitative and quantitative)	Nutrition competence: reported competency scores increased post training/mentoring. An increase in post-intervention measures was also observed: [69.1(13.8) to 79.3(12.1), $P < 0.001$]
Puoane et al. (38), South Africa	Pre-post-intervention study (with a qualitative design)	Nurses	A 5-days course developed by the University of West Cape was administered. It involved practice sessions, group work, role-plays, development of an action plan, key messages, and question and answer sessions. The course followed the principle of care set out by WHO for managing severe malnutrition	Post-intervention (training)	Practice: in-patient care for malnutrition management improved after the training. This included adequate follow-up on the 10 steps to management of malnutrition

(Continued)

Table 7 | Continued

Author	Study design	Health cadre	Intervention	Comparison	Outcome: nutrition management or practice
Hamer et al. (39), Gambia	Pre–post-intervention study	Registered and auxiliary nurses	Nutrition training for nurses was conducted using the IMCI training manual, “Assess and classify sick children aged 2 months to 5 years.” It included both theoretical and practical components of assessing children with and without wasting and/or edema admitted to the hospital	Post-training evaluation	Practice: in assessing undernutrition, nurses showed a 56% sensitivity, 95% specificity, and 56% positive predictive value (PPV)
Edwards and Wyles (40), UK	Pre–post-intervention study	Midwives, physicians, dieticians, and nurses	A total of 24 1-h training sessions were held, reaching 189 staff. Each session consisted of factual information, a brainstorming session about what a pregnant woman eats, and a nutrition game involving calculation of daily requirement for folic acid	Post-training evaluation	Practice: in a nutrition game, a high average intake of folic acid was observed in the chosen food items. It ranged from 244 to 500 μg compared to only 219 μg shown in average in census data on the same population
O’Mahony et al. (41), UK	Pre–post-intervention study	Nursing staff	Nutrition training was conducted with nurse participants. It also included the use of the Malnutrition Universal Screening Tool (MUST)	Post-training evaluation	Practice: 94% of nurses weighed patients on admission post-training compared to 74% before ($P < 0.001$)
Olsson et al. (42), Sweden	Pre–post-intervention study	Nurses	Nutrition education for nurses was conducted for 3 months. Training was based on the use of nutrition assessments including energy intake, clinical complication of inadequate energy intake, hospital food energy content, patients’ energy requirements, weighing patients and its necessity, reasons for weight loss during illness, and fluid management	Post-training evaluation	Practice: compared to pre-training, during post-training, nurses were more likely to use food forms to document food intake ($P < 0.01$)
Pedersen et al. (43), Denmark	Pre–post-intervention study	Nurses	Nutrition training was conducted for nurses. It included five modules spanning 3–4 days using the theory of planned change. The intervention involved basic nutrition education elements such as risk assessment, consequences of malnutrition, and assessment of needs and responsibility	Post-training evaluation	Practice: after the training, more patients reported eating difficulties to staff ($P = 0.01$), none reported not receiving help in cutting their food ($P = 0.014$), fewer had difficulty in chewing ($P = 0.01$), and fewer reported not receiving food they did not order ($P = 0.01$)
Kennelly et al. (45), Ireland	Pre–post-intervention study	General practitioners-doctors	Seven general practitioners participated in the nutrition education program. A community dietician used a standardized presentation to conduct the program. The content of training included information on causes of malnutrition, effects of malnutrition, the use of MUST, practical dietary advice to patients with poor appetite, and evidence supporting the use of oral nutrition supplements (ONS)	Post-training evaluation	Practice: about 62% completed a nutrition screening tool (MUST) on referral to a community dietician compared to 0% pre-intervention ($P < 0.001$). A greater proportion of patients with high risk of malnutrition were prescribed ONS post-training compared to pre-training (88% vs. 37%, $P < 0.001$)

(Continued)

Table 7 | Continued

Author	Study design	Health cadre	Intervention	Comparison	Outcome: nutrition management or practice
Kennelly et al. (44), Ireland	Pre–post-intervention study	General practitioners (GP) and nurse practitioners	An educational program incorporating MUST training was implemented in 8 of 10 eligible primary practices, 7 private nursing homes, and 2 health centers. The training program was designed based on consultations with health professional groups, clinical guidelines from expert bodies, and current evidence for ONS use in community settings	Post-training evaluation	Practice: management of malnutrition improved post training. About 69% of HCWs weighed patients more frequently and 80% reported on the usefulness of MUST
Simoes et al. (46), Ethiopia	Pre–post-intervention study	Clinic nurses	A 9-day course using the pre-tested version of the IMCI course was provided to six clinic nurses. The training modules included assessment and classification of a sick child, treatment of the child, counseling the mother, and follow-up. Other modules included practical sessions in the clinic	Post-training evaluation	Practice: compared to pediatricians, the trained nurses could diagnose malnutrition and anemia classified as severe or some malnutrition at a sensitivity of 85% and specificity of 96%
Stark et al. (49), US	Quasi-experimental design	Nutrition and health professionals	An online professional development program for nutrition and health practitioners course was given to the intervention group for 6 weeks. It was based on the PRECEDE-PROCEED health program planning framework involving assessing underlying factors for a health problem and strategizing the intervention	Delayed intervention control group	Nutrition management skills: compared to the control group, the intervention group reported positive changes ($P < 0.01$) on knowledge and skills scores
Charlton et al. (24), Zambia	Pre–post-intervention study	Health workers of growth monitoring and promotion	Eight out of 16 HCWs received the Growth Monitoring and Promotion (GMP) training. Details of the training including duration and contents were not explained	Post-training evaluation	Practice: trained HCWs could correctly interpret growth cards and complete the under-five card compared to their untrained counterparts ($P < 0.05$)

IG, intervention group; CG, control group; HCWs, health care workers.

through nutrition training is more likely to influence counseling behavior (27). Further, according to Bandura's social learning theory, such behavior or attitude change is mediated through cognitive processes and thus is learned through imitating and observing the actions of others (27). Accordingly, the reward that health workers can gain from their nutrition-counseling actions, such as better nutritional status or feeding practices in those they treat, may reinforce their counseling actions, thus making it a permanent habit. In this way, the quality of health workers with regard to nutrition counseling might be expected to improve.

Our review showed that health workers' undernutrition management practices improved when they received in-service nutrition training. A total of 16 intervention studies, including three cluster RCTs, showed a significant improvement in management practices for child undernutrition after nutrition training. Barriers to effective management of child undernutrition include lack of nutrition knowledge and counseling skills among health providers (12). Such barriers can be ameliorated when health workers receive

appropriate and tailored in-service nutrition training suited to their context and cadre.

Findings from this review should be carefully considered in the context of two primary limitations. First, the results are not based on meta-analysis to calculate the overall effect size of the intervention for each outcome variables. This was due to variations in the study designs and measurements used for outcome variables, and to differences in the competence, experience, and cadres of participating health workers. Such variations could have resulted in high heterogeneity. Hence, instead of meta-analyses, we explained each study separately in a narrative summary stratified by outcome variable. Although we did not pool our results, individual studies showed a significant effect of nutrition interventions on outcome variables.

Second, the included studies differed in the intervention's length and content. This might have caused differences in the measured outcome variables. However, most of the studies used standard nutrition training frameworks for health workers including the IMCI nutrition-counseling training module, breast-feeding

counseling training modules by both WHO and UNICEF, MUST training modules, and other comparable training based on formative research. Despite such differences, each study showed a significant improvement in one or more of the outcome variables.

Despite its limitation, findings thus presented may help decision makers to plan and conduct in-service nutrition training for health workers, an important building block toward building a strong foundation for any health system. This review is the continuation of series papers on the effectiveness of nutrition training of health workers. It is the first systematic review on the effectiveness of nutrition training for health workers on their nutrition knowledge, nutrition counseling, and undernutrition management skills. The other paper in the series found that, nutrition training of health workers improved feeding frequency, energy intake, and dietary diversity of children aged 6 months to 2 years (28).

In conclusion, in-service nutrition training of health workers improves their nutrition knowledge, nutrition and general counseling skills, and undernutrition management skills. Such nutrition training within the context of their practice is of paramount importance due to inadequate nutrition training in the health workers' mainstream medical and nursing education. In-service nutrition training can take different forms such as compulsory

CME, nutrition seminars, workshops, or non-compulsory continuing professional education CPD. Whatever form it takes, nutrition training has the potential to improve the quality of health workers, making them more confident and competent in this key area and thus contributing to positive changes in population nutrition.

AUTHORS' CONTRIBUTIONS

Bruno F. Sunguya conceived the research questions, designed the study, participated in the literature review and analyses, and prepared the first draft. Krishna C. Poudel refined the research question and the first draft. Linda B. Mlunde contributed to the study design, participated in the literature review, and helped to prepare the first draft. David P. Urassa revised the protocol. Junko Yasuoka participated in the preparation of the first draft and revisions. Masamine Jimba reviewed the study protocol and manuscript, and approved the submission. All authors read and approved the final version of the manuscript for submission.

ACKNOWLEDGMENTS

This study was funded by the Ministry of Health, Labor, and Welfare of Japan (Research Grant No. H24-chikyukibo-Ippan-008). The funders did not influence the review process or interpretation of findings.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received: 26 July 2013; accepted: 09 September 2013; published online: 24 September 2013.

Citation: Sunguya BF, Poudel KC, Mlunde LB, Urassa DP, Yasuoka J and Jimba M (2013) Nutrition training improves health workers' nutrition knowledge and competence to manage child undernutrition: a systematic review. *Front. Public Health* 1:37. doi: 10.3389/fpubh.2013.00037

This article was submitted to *Public Health Education and Promotion*, a section of the journal *Frontiers in Public Health*.

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STUDY PROTOCOL

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Efficacy of in-service nutrition training for mid-level providers to improve feeding practices among HIV-positive children in Tanga, Tanzania: study protocol for a cluster randomized controlled trial

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Abstract

Background: Feeding practices and child undernutrition can be improved when trained health workers provide proper nutrition counseling to caregivers. However, this important management component is difficult to achieve in countries where trained health workers are limited; Tanzania is no exception. In rural and semi-urban areas, mid-level providers (MLPs) are left to manage diseases such as HIV/AIDS. Training health workers in nutrition has been shown to be an effective intervention among HIV-negative children elsewhere, but no studies have been conducted among HIV-positive children. Furthermore, in Tanzania and other countries with MLPs, no evidence currently exists demonstrating an improvement in nutrition among children who receive health services given by MLPs. This study thus aims to examine the efficacy of nutrition training of MLPs on feeding practices and the nutrition status of HIV-positive children in Tanga, Tanzania.

Methods/Design: We will conduct a cluster randomized controlled trial in care and treatment centers (CTCs) in Tanga, Tanzania. The CTCs will be the unit of randomization. We will select 16 CTCs out of 32 for this study, of which we will randomly assign 8 to the intervention arm and 8 to the control arm by coin flipping. From the selected CTCs we will attempt to recruit a total of 800 HIV-positive children aged 6 months to 14 years, half of whom will be receiving care and/or treatment in the CTCs of the intervention arm, and the other half of whom will be receiving care and/or treatment in the CTCs of the control arm (400 children in each condition). We will provide nutrition training to MLPs of the CTCs selected for the intervention arm. In this intervention, we will use the World Health Organization guidelines on nutrition training of health workers for HIV-positive children aged 6 months to 14 years. The trained MLPs will then provide tailored nutrition counseling to caregivers of children being treated at the 8 CTCs of the intervention arm. We will measure nutrition status and child feeding practices monthly for a total of six months.

Conclusions: Results of this trial will help expanding undernutrition interventions among HIV-positive children in Tanzania and other countries.

Trial registration: Current Controlled Trials: ISRCTN65346364.

Keywords: Children, HIV/AIDS, Feeding practices, Mid-level providers, Nutrition status, Undernutrition

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Background

HIV/AIDS has exacerbated childhood undernutrition in developing countries and has led to a high mortality rate [1]; Tanzania is no exception. Among the general population of Tanzania, about 5.7% (2 million) were estimated to be living with HIV/AIDS in 2009. Meanwhile, 47.8% of children in the general population suffer from stunting or a chronic form of undernutrition [2]. Undernutrition among HIV-positive children remains a serious problem, even when antiretroviral therapy (ART) is administered [3]. In Tanzania, ART-treated, HIV-positive children were more likely to suffer from being underweight (4.6 times) and from wasting (9.6 times) compared to HIV-negative children [3].

Among HIV-positive children, undernutrition can be controlled if well-trained health workers counsel caregivers frequently [4,5]. By knowing the determinants of undernutrition in the specific population, such nutrition counseling can be carried out much more easily. The counseling may also focus on feeding behaviors and practices using locally available foods. Nutrition monitoring and early treatment of undernutrition also prevent further deterioration among children with pre-existing undernutrition. However, as the number of trained health workers in Tanzania is limited [6], such children have continued to suffer an unacceptable toll of undernutrition [3,7]. Semi-urban and rural areas bear the biggest brunt, and while mid-level providers (MLPs) are based in these areas [8], they are often not trained enough to ensure appropriate nutritional support of these children.

MLPs usually treat simple and specific diseases and perform simple surgical procedures [9]. They are health workers with 2–3 years of post-secondary school health-care training who undertake tasks usually carried out by doctors and nurses [9]. The MLPs' training focuses on major ailments specific to the populations they serve. In Tanzania, like in many other developing countries, such health cadres are commonly found in small cities and semi-urban and rural areas. In the 1960s, Tanzania introduced MLP cadres to solve the health workforce crisis in the country. Their training, however, lacks basic scientific components such as nutrition science as well as skills such as counseling, both of which are vital in helping people to improve their feeding practices and management of undernutrition. As a result, MLPs do not always have adequate knowledge and skills to manage child undernutrition, especially when it is complicated by HIV/AIDS.

In-service nutritional training of qualified health workers, such as medical doctors, nurses, nurse-midwives, nutritionists, and dieticians, can improve feeding practices including feeding frequency, dietary diversity, and energy intake among HIV-negative children aged 6

months to 2 years [10]. Nutrition counseling has been shown to have a positive effect on complementary feeding and nutrition status of children when it is provided by health workers who themselves received in-service nutrition training [11-13]. However, the evidence for such positive effects is only available for HIV-negative populations managed by well-trained health workers such as doctors and nurses—not MLPs. Furthermore, even in the case of well-trained health workers, the evidence base for the effectiveness of such interventions in sub-Saharan Africa is lacking. It is therefore difficult to generalize the results of the effectiveness of in-service nutrition training of qualified health workers to the HIV-positive children and health cadres below the qualified medical personnel in sub-Saharan Africa. This study's main objectives are to examine the efficacy of nutrition training of MLPs on improving feeding practices and the nutrition status of HIV-positive children, as well as to improve the MLPs nutrition knowledge, management, and counseling skills in relation to child undernutrition, in Tanga, Tanzania.

Methods/Design

Study area

We will conduct this study in HIV Care and Treatment Centers (CTCs) in Tanga, in the North Eastern region of Tanzania. Tanga is a coastal region with varied climatic conditions that allow diverse food production. Even if sisal market exports are lost, Tanga remains one of the main producers of cereals and fruits, and these make up a large part of its major economic activities.

Tanga is a food secured region; however, it has an unacceptably high proportion of child undernutrition. For example, in the nationally representative survey in 2010, more than 49% of the 315 under-five children surveyed in the Tanga region were stunted [2]. Acute undernutrition among them is also rampant; about 12% of the 315 under-fives were underweight while 5.5% were suffering from wasting. The regional diversity in food production does not reflect diversity in consumption. For example, Tanga produces various cereals, fruits, vegetables, and both fresh and sea water products; however, only 59.4% of the 292 children aged 6 to 60 months sampled from the general population consumed foods rich in vitamin A [14]. The proportion of vitamin A deficiency among these children was 38.9%, iron deficiency was 36.5%, and iron deficiency anemia was 52.2% [14].

The region is also not spared by HIV/AIDS epidemic. The prevalence of HIV/AIDS in the region is estimated to be 2.4%, based on a sample of 833 adults aged 15 to 49 years old who were tested as part of a nationally representative survey [15,16]. Data of nutrition profiles of HIV-positive children in this region is not available.

CTCs are specialized clinics to care for HIV-positive people, including children. They operate under vertical HIV programs and are integrated into the existing health infrastructure [17]. In Tanga, all CTCs are located in health facilities. They provide care and treatment to HIV-positive people including voluntary counseling and HIV testing, prescribing and dispensing ART, ART adherence counseling, diagnosis and treatment of opportunistic infections, monitoring response to treatment and disease progression, behavior change promotion, and outreach services, among others [15,17]. HIV-positive people attend CTCs every month to get ART refills. In each visit, they also receive adherence counseling and monitoring, examination by clinicians, and management of opportunistic infections, if any [15,17].

Until December 2012, the Tanga region had a total of 32 CTCs. They are distributed throughout the region based on population density and the needs of specific areas. All districts have CTCs located in the district hospital and health centers. A total of 20,773 people living with HIV/AIDS were enrolled at these CTCs by the year 2009 [15]. According to regional unpublished data, about 1,800 HIV-positive children were enrolled at CTCs for care and treatment as of March 2013.

Study design

We will conduct a cluster randomized controlled trial in Tanga, Tanzania. We will select 16 CTCs out of 32 for this study (Figure 1). The selected CTCs are located in public health facilities and have at least 20 enrolled HIV-positive children. We will use the coin-flipping method to randomly assign 8 CTCs to the intervention arm and 8 to the control arm (Figure 1). We will examine the effectiveness of nutrition training of MLPs on their nutrition knowledge, management of undernutrition, feeding practices, and the nutrition status of HIV-positive children attending CTCs. The intervention follows formative research conducted using focus group discussions and a cross-sectional study to examine factors associated with undernutrition, available foods, and local feeding practices for the children in this population. Results of the formative research are in the process of being published in another journal.

Baseline

We will assess nutrition status and feeding practices (feeding frequency, dietary diversity, quality and quantity of food items consumed in the previous 24 hours) of the recruited children. We will investigate the burden of disease caused by opportunistic infections, diarrhea,

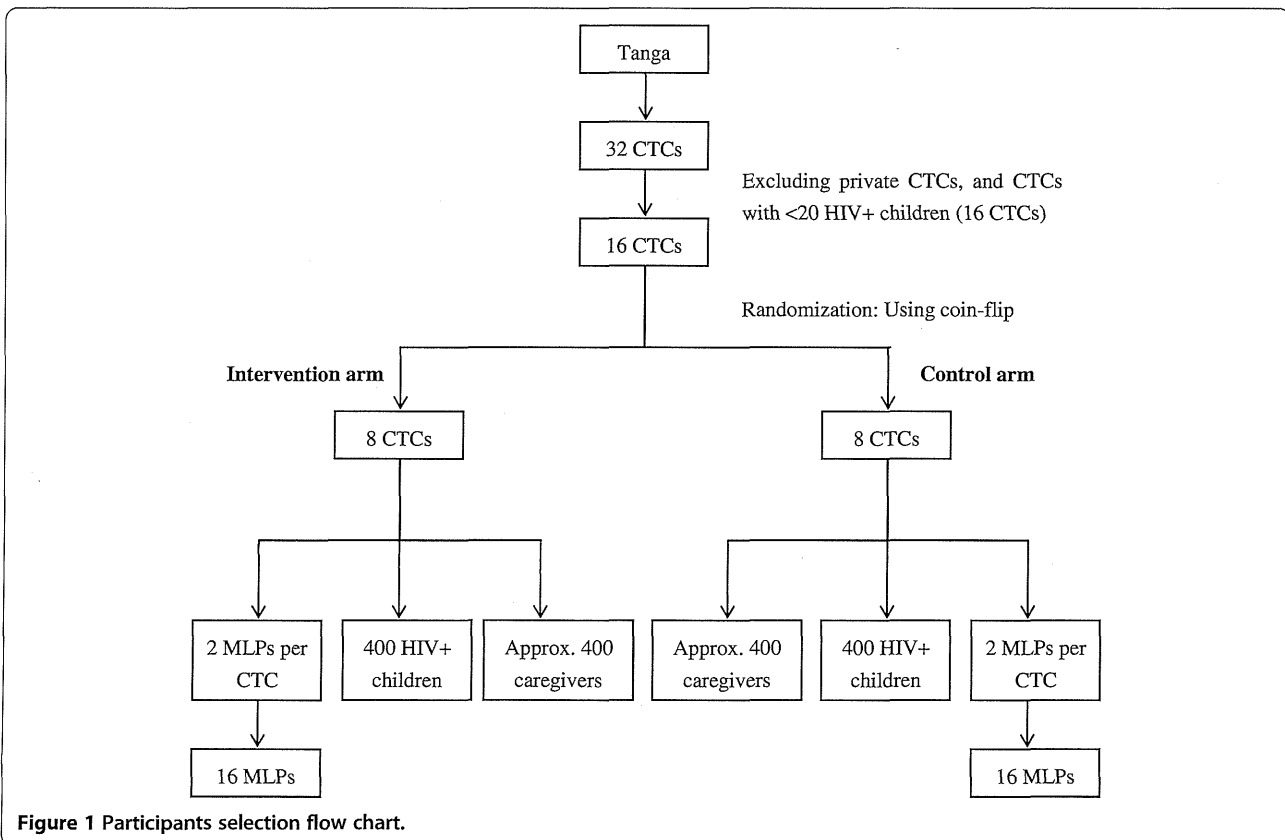


Figure 1 Participants selection flow chart.

malaria, and intestinal helminthes. We will also assess MLPs' nutrition knowledge and skills for managing undernutrition in children living with HIV/AIDS before and after the training.

Intervention

We will conduct in-service nutrition training of two MLPs selected from each of the CTCs in the intervention arm, providing training on how to prevent, diagnose, and manage undernutrition based on the identified local determinants of undernutrition. The training methods will be adopted from the standard *Integrated Management of Childhood Illness: Counsel the Mother* handbook [18] and the *Guidelines for an Integrated Approach to the Nutritional Care of HIV-infected Children (6 months to 14 years)* [19].

At the end of the nutrition training, health workers are expected to improve in two competencies: knowledge on nutrition and feeding practices and skills on managing and providing nutrition care for HIV-positive children [19]. We will provide pre-course materials that include information on HIV/AIDS-staging, basic counseling skills, and basic information on complementary feeding of children to the MLPs.

The course structure includes 18 sessions of lectures, demonstrations, practice sessions, exercises, and role-play. According to the standard WHO training guide [19], this training will take 13 hours and 40 minutes. We will conduct this training over the course of two consecutive days. Table 1 contains the estimated duration and description of each session.

According to the requirements set by the training guide, we will select trainers who are experienced in teaching the IMCI guide, managing undernutrition and HIV/AIDS among children, counseling, and recommending feeding practices for children [19]. We will include one pediatrician, one nutritionist, and one psychologist in the team of trainers. They will be provided with the trainer's guide and the participants' guide, as well as the booklet that comes along with the other training materials [19].

The trained MLPs will provide nutrition counseling to caregivers and will separately undertake direct measures for managing undernutrition to the HIV-positive children attending the CTCs of the intervention arm on a monthly basis for six months of the follow-up period. A similar intervention will be made available for the control group after evaluating the results.

Follow-up

We will follow-up both intervention and control groups for 6 months. We will evaluate feeding practices, such as feeding frequency, dietary diversity, and quality and quantity of food eaten by children, as well as nutrition

Table 1 Nutrition training content and session duration

Session	Content	Session duration
Session 1	Introduction	15 minutes
Session 2	Review of pre-course materials	60 minutes
Session 3	Assess growth using growth charts	40 minutes
Session 4	Measuring growth using growth charts	30 minutes
Session 5	Listening and learning counseling skills	30 minutes
Session 6	Clinical signs of malnutrition in a child	30 minutes
Session 7	Practical session 1: Assessing and classifying a child's weight and growth	120 minutes
Session 8	Assess child's nutrition needs	30 minutes
Session 9	Decide on a Nutritional Care Plan	60 minutes
Session 10	What does the child eat or drink?	45 minutes
Session 11	Who feeds the child and how does the child eat?	30 minutes
Session 12	Food security	30 minutes
Session 13	Building confidence and support skills	30 minutes
Session 14	Practical session 2: Assessing and classifying a child's nutritional status	120 minutes
Session 15	Exercise, risk factors and referral	30 minutes
Session 16	The HIV-infected child with special needs	60 minutes
Session 17	Children on antiretroviral treatment	30 minutes
Session 18	Conclusion and competencies	30 minutes

Total training duration 13 hours 40 minutes.

status, on a monthly basis for six months. For the intervention arm, we will also measure nutrition knowledge of MLPs before the training, immediately after the nutrition training, and again after the six-month observation period in order to measure the degree of knowledge decay.

Participants and selection criteria

Participants of this study will include MLPs who manage HIV-positive children attending the CTCs in Tanga and pairs of HIV-positive children and their caregivers.

Midlevel providers (MLPs)

We will invite a minimum of two MLPs from each CTC of the intervention arm to take part in the nutrition training. We will also recruit a similar number of MLPs from the CTCs of the control arm. A total of 32 MLPs will participate in this study. MLPs include assistant medical officers, clinical officers, allied health workers, and nurse assistants. We will exclude all other health workers that do not fulfill the MLP criteria as per its definition. Such health workers include health promotion volunteers and non-clinician, home-based care staff.

HIV-positive children

We will recruit HIV-positive children attending the selected CTCs. Inclusion criteria for participation of the