Improving dietary diversity and food security among low-income families during financial crisis using cash transfers and mHealth: experience from two selected districts in Sri Lanka

Millawage Supun Dilara Wijesinghe[1], Upeksha Gayani Karawita[1*], Nissanka Achchi Kankanamalage Ayoma Iroshanee Nissanka[1], Balangoda Muhamdiramlage Indika Gunawardana[1], Weerasinghe Mudiyanselage Prasad Chathuranga Weerasinghe[1], Yakupitiyage Asanka Supun[2], Dilka Rashmi Peiris[3], Roshan Dela Bandara[2] and Ranjith Batuwanthudawe[1]

Abstract

Background The economic crisis in Sri Lanka worsened food insecurity, with millions facing moderate-to-severe food shortages. This study evaluates the effectiveness of cash transfers combined with mobile health education in enhancing dietary diversity and food security among Sri Lankan households during the crisis.

Methods This quasi-experimental single-group pre-post study involved 1040 eligible individuals selected through stratified random sampling from eligible households of Samurdhi beneficiaries and smallholder farmers. The intervention included a cash transfer of LKR 22,500 and weekly nutrition awareness messages via WhatsApp and SMS complemented by a one-time awareness session. Dietary diversity and food security were assessed using standard validated tools such as the Diet Quality Questionnaire and Food Security Questionnaire.

Results Food insecurity decreased significantly from 89.3% ($n = 681$) in the pre-test to 76.9% ($n = 533$) in the post-test, with a 12.4% reduction (95% CI, 8.57 to 16.24, $p < 0.05$). The Minimum Dietary Diversity for Women improved from 44.5 to 67.8% [23.3% increase (95% CI, 15.89 to 30.63; $p < 0.05$)]. The mean NCD-Protect and GDR scores increased significantly, indicating a higher adherence to global dietary recommendations, whereas the NCD-risk scores remained unchanged.

Conclusions This study demonstrated that cash transfers combined with mobile phone-based nutritional education significantly improved dietary diversity and food security among low-income families in Sri Lanka during the financial crisis.

*Correspondence:
Upeksha Gayani Karawita
ugkarawita@gmail.com

Full list of author information is available at the end of the article

Introduction

The number of hungry or undernourished individuals has increased since 2015, especially in Africa, West Asia, and Latin America, where it now affects one in nine people worldwide [1]. The global rise in hunger and undernutrition since 2015 has been driven by multiple factors including conflict, climate change, and economic shocks. Conflicts in regions such as sub-Saharan Africa and the Middle East have disrupted food systems, whereas extreme weather events due to climate change, such as droughts, have worsened food insecurity, particularly in the Horn of Africa [2]. The COVID-19 pandemic has exacerbated the situation by disrupting livelihoods and global food supply chains, pushing 97 million people into poverty [3]. Additionally, economic inequality and rising food prices have made nutritious diets unaffordable for many [2]. It was well identified that food insecurity is a major contributor to poor health and nutritional deficits worldwide [4]. People with adequate nutrition are more productive and can gradually create opportunities to break the cycles of poverty and hunger. Adequate nutritional intake helps reduce the risk of noncommunicable diseases (NCDs) and increases longevity [5].

Undernutrition, overnutrition, and micronutrient deficiencies are the three forms of malnutrition affecting the world, particularly in low- and middle-income countries, such as Sri Lanka [1]. Each type of malnutrition poses a serious risk to human health. According to the latest statistics, approximately 10% of children under the age of five suffer from wasting, 17% are underweight, and 10% are stunted in Sri Lanka [6]. Additionally, the low birth weight rate of children in Sri Lanka is 15.7% [7]. With the current economic turmoil, approximately 3.9 million people (17% of the population) were estimated to be moderately acute food insecure and 10 000 people were severely food insecure [8]. In marginalised areas, poor eating practices are eminent, leading to macronutrient imbalance and micronutrient deficiency. In addition, it is estimated that 63.2% of women of reproductive age do not meet the criteria for minimum food diversity and security [9]. Furthermore, the situation is predicted to worsen if inadequate lifesaving assistance and livelihood support are not provided [8].

mHealth, or mobile health, refers to the use of mobile devices such as smartphones, tablets, and other wireless technologies to support healthcare and public health practices. It encompasses a wide range of applications, including health monitoring, diagnostic tools, communication between healthcare providers and patients, remote patient monitoring, and health education [10]. The use of mHealth to improve nutrition knowledge and practice is a novel method in many countries. For example, the Mobile Alliance for Maternal Action (MAMA) supports country programs in Bangladesh, India, South Africa, and Nigeria, and delivers vital health messages to new and expectant mothers via their mobile phones and mHealth SMS text messaging services to improve maternal, foetal, and infant health outcomes [11]. "Aponjon" (a mobile phone-based mHealth service) is another such a programme which is operating in Bangladesh, under the MAMA program for expecting and new mothers [12]. The importance of mHealth is also highlighted in studies in the region, which suggest that text message-based mHealth interventions in under-resourced settings could be encouraged and may result in higher service coverage and ultimately improve health and nutrition practices [13]. Furthermore, the use of mHealth to improve nutrition education has been documented and found to be effective among pregnant and nursing mothers in Sri Lanka [14].

In this note, nutrition-related practices can be reinforced by nutrition education using mHealth to change behaviours and habits that contribute to poor health during crises. This can be done by creating motivation for change among people to establish desirable food and nutritional behaviours to promote and protect good health. In addition, people are encouraged to learn new nutritional information and develop the attitudes, skills, and confidence needed to improve their nutrition [15]. However, there is limited evidence regarding the effectiveness of mHealth interventions in lower middle-income countries (LMIC) [16]. Furthermore, current evidence is insufficient to determine the effectiveness of mHealth in promoting healthy eating among adults [17]. Therefore, this study aimed to evaluate an intervention targeting cash transfers and a mobile phone-based health education intervention for Samurdhi beneficiaries and smallholder farmers during the economic crisis, and whether the intervention had improved dietary diversity and household food security.

Methods

We conducted a quasi-experimental single-group pre-post study in the Divisional Secretariat (DS) of the Mulathiv and Monaragala districts (Fig. 1). There are 25 District Secretariats in the country, each of which corresponds to one of the 25 administrative districts. Led by a District Secretary, these secretariats oversee the
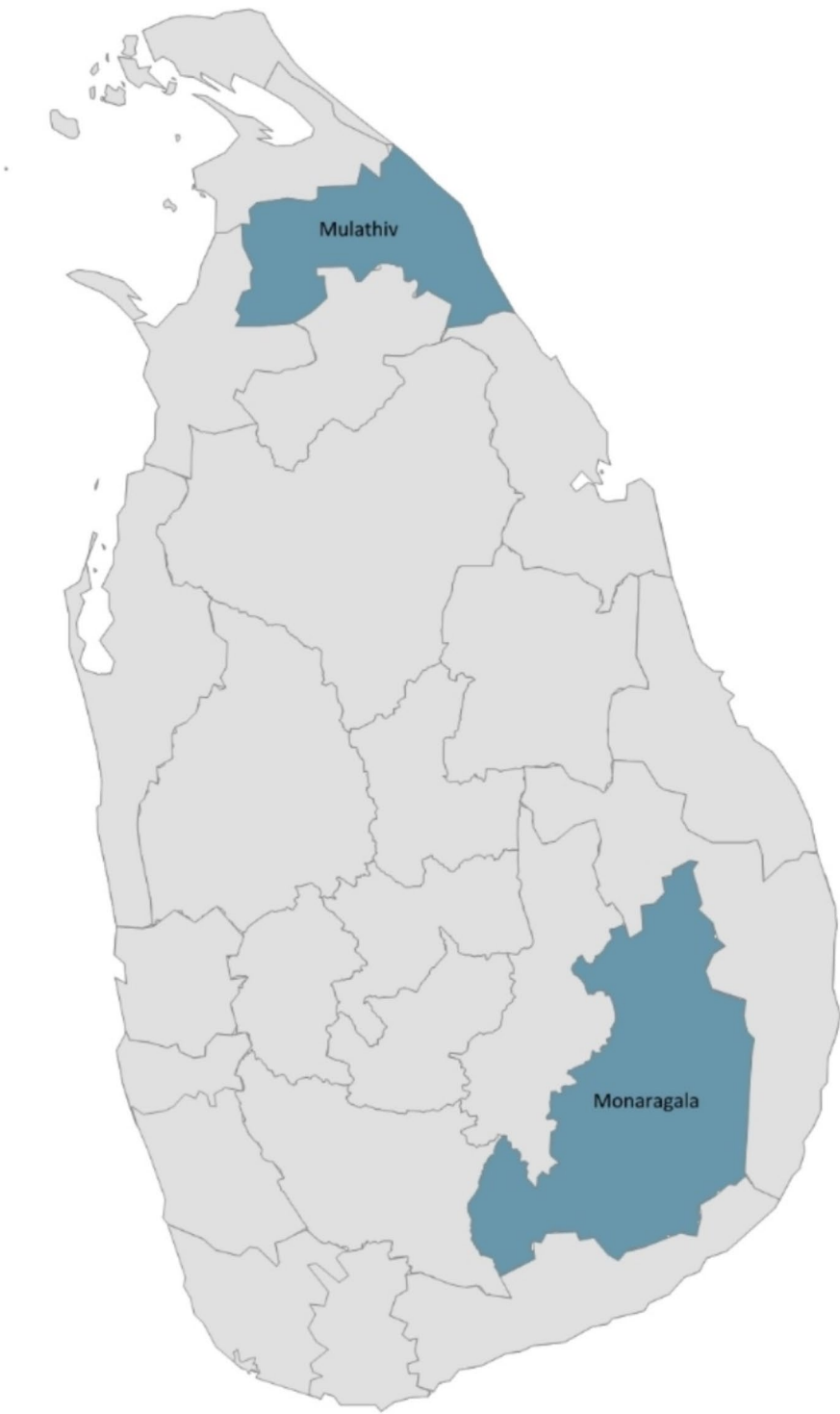
Fig. 1 Map of Sri Lanka showing study areas

Divisional Secretariats, with each district typically having five to 25 Divisional Secretariats under its jurisdiction. As a result, Divisional Secretariats provide administrative coverage across the entire island [18]. The DS areas were selected according to the recommendations of the Department of Samurdhi Development. Monaragala district consists of 11 DS areas: Sevenagala, Thanamalwila, Wellawaya, Buttala, Monaragala, Siyambalanduwa, Madulla, Bibile, Medagama, Badalkumbura, and Kataragama. The Mullaitivu district consists of six divisional secretariat areas: Manthai East, Thunukkai, Maritime Pattu, Oddusudan, Pudukkuduirippu, and Welioya. Three DS areas (Thanamalwila, Wellawaya, and Siyambalanduwa) were selected from the Monaragala District. All six DS areas were selected from Mullaitivu District. This study was conducted between November 2022 and March 2023. In 1994, the Samurdhi Program was launched by the newly elected Sri Lankan Government as a national strategy to alleviate poverty and the Samurdhi Ministry was established. The present government is likewise committed to the ideals and goals of the programme and plans to further intensify and improve the approach based on its initial experiences are under way. This programme covers one-third of the entire population of Sri Lanka, with about 1.2 million poor families. It is funded in its entirety by the Government of Sri Lanka [19]. A Samurdhi beneficiary who is a permanent resident of the Area of Authority, being an adult with the appropriate physical and mental fitness, is eligible to obtain membership in a Samurdhi community-based organisation [20].

All eligible households of Samurdhi beneficiaries (consisting of a household with a pregnant mother or a nursing mother, household with a child under five years, households with a chronic illness, households with a disability), and smallholder farmers in the Mulathiv and Monaragala districts. These strata are the categories used by the Department of Samurdhi Development. Samurdhi beneficiaries are the lowest-income category identified by the government to provide subsidies from 1995. Smallholder farmers were also identified in the low-income category in these areas.

Study population
The sample size was calculated using a standard formula [21]. The estimated sample size was 1040 individuals. Stratified random sampling was used because a complete sampling frame was available. There were 4,250 families of Samurdhi beneficiaries and 570 smallholder farmers residing in both Mulathiv and Monaragala districts. The total population is 4820. The lists were provided by DS office officials. Those who had temporarily stayed in the area and had not stayed in the area within the last six months before project initiation were excluded. After identifying the five strata of this population named "families with a pregnant or nursing mother", "families with children under five years", "families with a disabled person", "families with a chronic disease person", and "families with smallholder farmers", stratified sampling method was used to select the families. In each stratum, 208 families were selected using a random number table.

Study instrument
A pre-tested interviewer-administered questionnaire was used to collect the data. Data were collected from the main beneficiaries of the selected families from Samurdhi beneficiaries and the breadwinners of the selected smallholder farmer families. The questionnaire consisted of two sections. Section one consisted of sociodemographic and economic details. Section two consisted of questions related to dietary assessment tools (dietary diversity and food security). Standard validated tools, such as the Diet Quality Questionnaire (DQQ) [22] and 6-item Food Security Questionnaire [23], were used. Interview guides were developed to maintain the uniformity of mobile phone-based data collection. We pretested the tool with ten participants.

Dietary assessment tools
For the purpose of our study, Dietary Diversity (DD) was defined as "the number of different foods or food groups consumed over a given reference period" [24]. Dietary diversity was measured using the Diet Quality Questionnaire (DQQ). This standardised, low-burden tool can be used for dietary assessment at the population level [25]. The DQQ consists of yes/no questions about the diet consumed in the previous 24 h. Scoring for each food group was binary (0: not consumed; 1: consumed). It corresponds to 29 food groups and has been validated in Sri Lanka [22]. The following indicators were calculated using the DQQ tool in the two selected districts, both pre- and post-intervention.

Diet Quality indicators
MDD-W
The Minimum Dietary Diversity score for women (MDD-W) was calculated using the following 10 food groups: (1) grains, white roots, tubers, and plantains; (2) pulses (beans, peas, and lentils); (3) nuts and seeds; (4) milk and milk products; (5) meat, poultry, and fish; (6) eggs; (7) dark green leafy vegetables; (8) other vitamin A–rich fruits and vegetables; (9) other vegetables; and (10) other fruits [25]. We used the normal standards for calculating the MDD-W of consumption of five or more of the above-mentioned food groups which indicates a higher likelihood of micronutrient intake for females aged 15–49 years [26–28]. The MDD-W was defined as a dichotomous indicator (0 or 1).

NCD-Protect score

The NCD-Protect score was calculated from nine food groups according to international literature [29, 30]. The nine food groups included: (1) whole grains; (2) pulses; (3) nuts and seeds; (4) vitamin A–rich orange vegetables; (5) dark green leafy vegetables; (6) other vegetables; (7) vitamin A–rich fruits; (8) citrus; and (9) other fruits. The NCD-Protect score was calculated by summing the scores of each food group, with a higher score indicating adherence to global dietary recommendations (GDRs) on healthy components.

NCD-Risk score

The NCD-Risk score was calculated from eight food groups according to the international literature: (1) soft drinks (sodas), (2) baked/grain-based sweets, (3) other sweets, (4) processed meat (double-weighted), (5) unprocessed red meat, (6) deep fried food, (7) fast food and instant noodles, and (8) packaged ultra-processed salty snacks. The NCD-Risk score ranges from 0 to 9 and reflects adherence to GDRs on diet components to limit or avoid. A higher score indicates a lower likelihood of meeting the GDRs on dietary risk factors for NCDs [29, 30].

GDR score

The GDR score is calculated by subtracting the NCD-Risk from the NCD-Protect and transforming it to a positive range by adding 9, and is expressed as the mean population score [29, 30]. The GDR score ranges from to 0–18 with higher scores representing more GDRs on a healthy diet.

Food security

For the purpose of this study, we defined food security as "the capacity of a household to procure a stable and sustainable basket of adequate food" [31]. We used the Household Food Security Survey Module: Six-Item Short Form [32]. We categorised food security status as follows: a score of 0–1; High or marginal food security; a score of 2–4; Low food security; a score of 5–6; Very low food security. Thereafter, for the purpose of analysis we amalgamated categories to make it dichotomous, 0–1 is defined as 'food secure' and the other two categories in combination as 'food insecure' [33].

Intervention

The intervention consisted of two components. The first component consisted of a cash transfer of LKR 22,500 to the beneficiary to purchase healthy and nutritious food for the household. The second component consisted of nutrition awareness messages on how to use cash for optimum nutrition of the family. The messages were developed by the principal investigator in consultation with other relevant stakeholders to ensure a consensus-based approach to content creation. Messages were developed under the themes of child feeding, feeding practices, food-based dietary guidelines, and cash management focusing on nutrition, gender, parental care, and food security. We used previously tested 19 text and social media messages. We developed messages in the Sinhala and Tamil languages using a simple and easy-to-understand language. The description of message development and sample content was similar to that described in our previous study [14]. The messages developed were tested on ten people who were not selected for this study. The messages were delivered through WhatsApp and SMS portals weekly. Participants with smartphones received messages via WhatsApp, whereas those without smartphones received messages via SMS. Although we did not specifically adapt the message format based on the phone type, the content was designed to be accessible across both platforms. In addition, a one-time awareness session was conducted by the researchers for the study participants with the coordination of the district Health Education Officers (HEOs) in the two districts. The session was planned midway through the intervention. The intervention lasted for eight weeks.

Data collection

We first collected phone numbers from the DS division list and recruited eligible participants over the phone for the study. The data were collected by trained enumerators. A total of 1040 participants were invited to participate in this study. Our primary approach was to contact the designated beneficiaries of the family for data collection across all components. If a beneficiary was unavailable, another household member answered the questionnaire. When the beneficiary was a child under five years of age, their mother or father provided responses. In the case of a beneficiary with a disability, if they were able to answer, we contacted them directly. If not, family members answered the questionnaire on their behalf. We were unable to trace 265 participants even after repeated attempts. The questionnaire was prepared using Kobo Toolbox, and a pre-test was administered to the participants. Following the intervention, the participants were contacted again for the post-test. A procedure similar to that used in the pretest was adopted.

Data analysis

We conducted a pre-post unmatched analysis of the data based on the collected indicators. Data were analysed using the Statistical Package for Social Sciences (SPSS) version 24. We conducted a descriptive analysis with frequency distribution for nominal variables, means and standard deviations for continuous variables, and percentages and 95% confidence intervals for

categorical variables. Statistical significance was set at $p<0.05$. Ethical clearance was obtained from the Post-graduate Institute of Medicine, University of Colombo, 160, Prof. Nandadasa Kodagoda Mw, Colombo 07, Sri Lanka. We obtained verbal and short mobile phone text-based informed consent from all participants (ERC/PGIM/2022/183).

Results

Out the 1040 selected participants in the initial study, 775 responded to the pre-test assessment with a response rate of 74.5%. We were unable to trace 265 participants because of incorrect addresses or phone numbers. In the post-assessment period, 693 participants responded, with a response rate of 89.4% (Fig. 2). We were unable to trace some participants because of incorrect contact information, and multiple attempts were made to reach them. Basic socio-demographic characteristics (age, respondent status, language reading, level of education, ownership of mobile phones, and usage of TV/radio) of

the participants who were lost to follow-up did not statistically differ from the study participants.

Socio-demographic characteristics of the participants

In the sample, nearly 61% ($n=472$) were from Monaragala district and 54.5% ($n=422$) were males, with 81% ($n=628$) in the age range of 31 years or more. The majority were of the Sinhala ethnicity (61%, $n=473$). Only 35.6% ($n=258$) of the participants used smartphones (Table 1). The majority stated that health messages were delivered through public health midwives, family members, or television (Supplementary Table 1). The majority of smartphone users used WhatsApp, YouTube, and Facebook social media platforms (Supplementary Table 2). Only 15.1% ($n=117$) of the participants verified the social media information they received.

The percentage of food insecurity in the pre-test (89.3%, $n=681$) reduced in the post-test (76.9%, $n=533$). The difference was 12.4% (95% CI, 8.57 to 16.24) which was statistically significant ($p<0.05$).
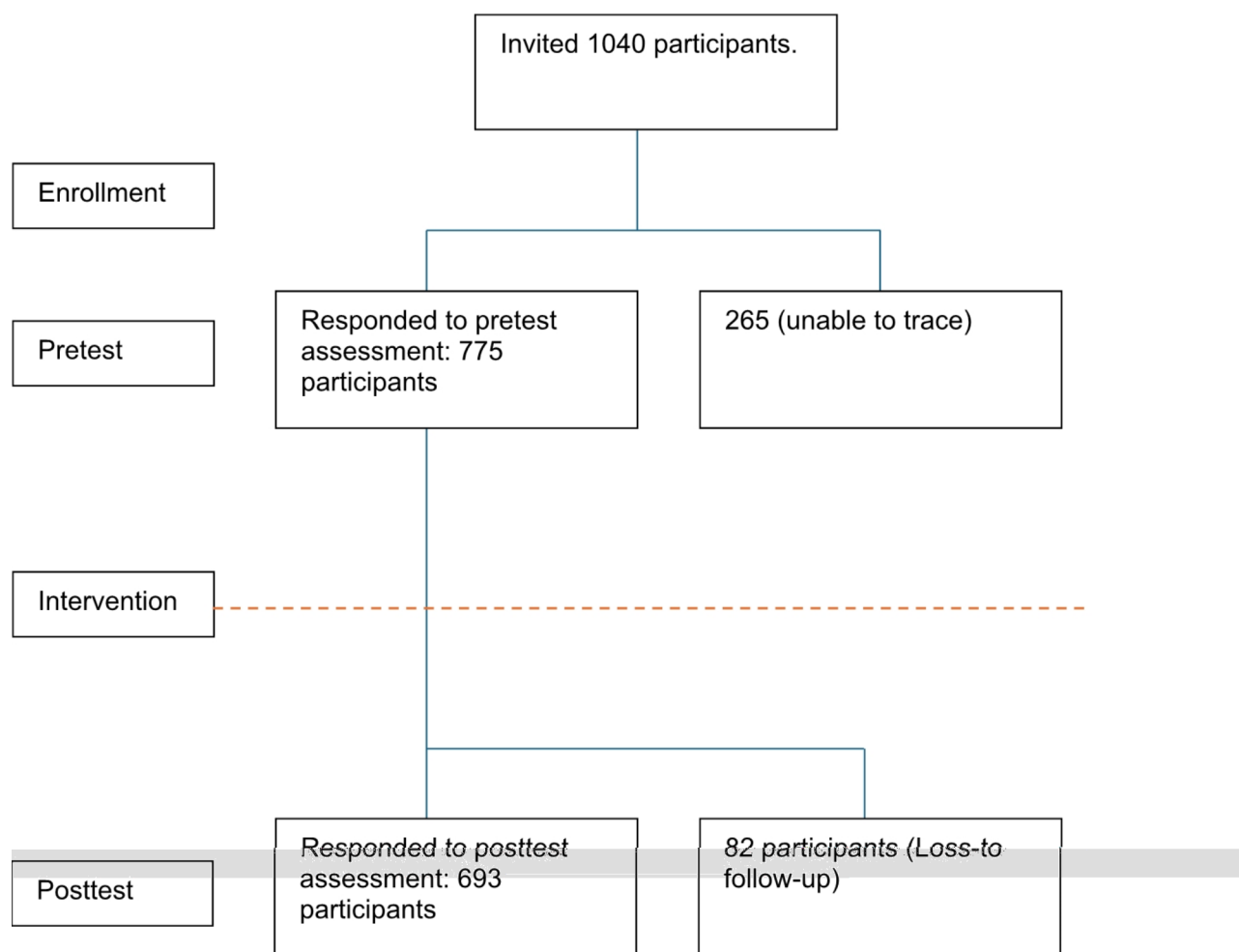
Fig. 2 Flow diagram of study participants at each stage

Table 1 Sociodemographic characteristics of the participants (*n* = 775)

Characteristic	Number	%
District		
Monaragala	472	60.9
Mullathiv	303	39.1
Sex		
Female	353	45.5
Male	422	54.5
Age		
16 years or less	4	0.5
17 years to 20 years	4	0.5
21 years to 30 years	139	17.9
31 years or more	628	81.0
Participant category		
Samurdhi beneficiary	614	79.2
Smallholder farmer	161	20.8
Samurdhi beneficiaries' subcategory based on family characteristics (n = 614)		
Pregnant mothers	19	3.1
Nursing mothers	135	22.0
Under 5 year children	152	24.8
People with disability	156	25.4
People with chronic diseases	152	24.8
Spoken Language		
Sinhala	473	61.0
Tamil	302	39.0
Reading Language		
Sinhala	472	60.9
Tamil	302	39.0
English	1	0.1
Education Level		
Grade 1 to 13	715	92.3
Graduate	4	0.5
Diploma and other professional qualification	3	0.4
No Schooling	53	6.8
Income		
Rs.10,000 or below	341	44.0
Rs.10,001 to Rs.20,000	253	32.6
Rs.20,001 to Rs.30,000	112	14.5
Rs.30,001 or more	69	8.9
No of Family Members		
1	26	3.4
2	122	15.7
3	208	26.8
4	221	28.5
5	154	19.9
6	34	4.4
7	08	1.0
8	01	0.1
9	01	0.1
Financially dependent family members		
0	130	16.8
1	121	15.6
2	178	23.0
3	183	23.6
4	130	16.8

Table 1 (continued)

Characteristic	Number	%
5	25	3.2
6	06	0.8
7	02	0.3
Food expenditure		
Rs.5000 or below	102	13.2
Rs.5001 to Rs.15,000	416	53.7
Rs.15,001 to Rs.30,000	234	30.2
Rs.30,001 or more	23	3.0
Phone type (n = 724)		
Feature Phone	466	64.4
Smart Phone	258	35.6

Table 2 Non-communicable disease -protect score, -risk score & Total GDR-score of the pre and post sample

Diet quality indicator	Pretest (n = 780)		Posttest (n = 694)		Significance
	Mean	SD	Mean	SD	
NCD Protect score	3.57	1.54	4.04	1.495	$P < 0.001$
NCD Risk score	1.97	1.678	2.02	1.494	$P = 0.545$
Total GDR score	10.60	1.653	11.02	1.827	$P < 0.001$

The Minimum Dietary Diversity for Women to measure micronutrient adequacy was 'adequate' in 44.5% (n = 158) in the pretest and it was increased to 67.8% (n = 206) in the post test. The difference was 23.3% (95% CI, 15.89 -30.63). The results were statistically significant (p < 0.05).

The mean NCD-Protect score and total GDR-score were higher in the post-test than in the pre-test, and the difference was statistically significant. However, the NCD-risk score remained more or less the same, and the difference was not statistically significant (Table 2). Table 3 shows the frequency distributions of food group scores for the NCD-Protect and NCD-risk scores.

Discussion

Our findings indicate that cash transfers and subsequent mobile phone-based nutritional education interventions are associated with improvements in dietary diversity and household food security in the target low-income population. By delivering messages through WhatsApp and SMS portals on a weekly basis, supplemented by one-time awareness sessions, we aimed to address the key nutritional challenges faced by low-income families during a financial crisis.

The majority of the participants in the study were male (54.5%). This differed from the general population characteristics of Sri Lanka, where the percentage of males was 49% [34]. However, this discrepancy can be attributed to the overrepresentation of Samurdhi beneficiaries and smallholder farmers, who predominantly consist of men and serve as primary breadwinners in their families. We prioritised the main beneficiary as the participant, and in cases where the main beneficiary was unavailable, we conducted surveys with family members.

The majority of the study participants (61.0%) belonged to the Sinhalese-speaking community, whereas only 39% were Tamil-speaking. The educational attainment of our study participants was evidenced by a major proportion

Table 3 Frequency table of total non-communicable disease-protect score, -risk score & Total GDR dscore of the sample

Score	NCD-Protect score				NCD-risk score			
	Pre (n = 780)		Post (n = 694)		Pre (n = 780)		Post (n = 694)	
	Frequency	(%)	Frequency	(%)	Frequency	(%)	Frequency	(%)
0	6	0.8	7	1.0	94	12.1	92	13.3
1	38	4.9	22	3.2	351	45.0	260	37.5
2	148	19.0	75	10.8	40	5.1	50	7.2
3	210	26.9	146	21.0	191	24.5	183	26.4
4	193	24.7	176	25.4	47	6.0	59	8.5
5	122	15.6	151	21.8	36	4.6	44	6.3
6	36	4.6	89	12.8	8	1.0	5	0.7
7	10	1.3	23	3.3	0	0	1	0.1
8	3	0.4	5	0.7	0	0	0	0
9	14	1.8	0	0	13	1.7	0	0

(92.3%) completing Grade 1–13 of education. However, it is noteworthy that a significant number of the participants (6.8%) reported no formal education. This finding highlights the presence of educational disparities within our study population, indicating barriers to accessing or completing formal schooling in a subset of individuals. To further contextualise our findings, we referred to census data from 2021, which indicated high literacy levels in both the Monaragala district (91.7%) and the Mullaitivu district (91.4%). This alignment with regional literacy rates suggests that our study sample is representative of a broader population in terms of educational attainment and literacy level [35].

The findings of this study revealed a notable reduction in the percentage of food insecurity from the pre-test to the post-test phases. Specifically, the proportion of participants experiencing food insecurity decreased from 89.3% in the pre-test to 76.9% in the post-test, representing a significant reduction of 12.4% (95% CI, 8.57–16.24). This substantial decrease indicates an improvement in the overall food security status of participants following the intervention. The observed shift towards a higher proportion of individuals experiencing food security further supports the effectiveness of the intervention in addressing nutritional needs and promoting food access within the study population. In providing a broader context, food insecurity remains a significant global challenge across various demographic groups. For example, a meta-analysis of 31 studies found that food insecurity affects 49.2% of Iranian households, 67.0% of children, 61.0% of mothers, 49.0% of adolescents, and 65.0% of the elderly [36]. These findings emphasise the pervasive nature of food insecurity and underscore the importance of targeted interventions, such as that used in this study.

The mean value of the total NCD-Protect score demonstrated an increase in the post-test phase compared with the pre-test phase, indicating a statistically significant improvement following the intervention. This observed increase in the mean NCD-Protect score suggests a positive impact of the intervention on participants' adoption of behaviours and practices known to mitigate the risk of NCDs. Specifically, this implies an enhancement in their adherence to health-promoting activities and preventive measures. The increase in the NCD-Protect score not only signifies a statistical improvement, but also underscores a potential enhancement in participants' overall health-related behaviours, such as dietary choices. Additionally, contextualising these findings within a broader global perspective, the comparison with NCD-Protect scores from India, Bangladesh, and Pakistan, which stood at 3.4, 2.9, and 3.2, respectively, underscores the relative efficacy of the intervention in the study population [37]. This cross-national comparison illuminates regional disparities and highlights potential areas for targeted interventions and policy implementations to effectively address diet as an NCD protective factor.

Although our NCD-risk score increase may appear modest, the absolute value signifies a participant's susceptibility to developing non-communicable diseases. Compared to Sri Lanka, neighbouring countries such as India, Bangladesh, and Pakistan (with scores of 1.5, 1.5, and 1.4, respectively) exhibit significantly lower NCD risk scores [37]. This discrepancy suggests a potentially distinctive health risk profile across these regions, highlighting the importance of dietary modification. There is a clear need for customised interventions and strategies to combat the prevalence of NCDs effectively.

Considering the GDR scores of neighbouring countries such as India, Bangladesh, and Pakistan, 10.9, 10.4, and 10.8, respectively [37], it is evident that the post-intervention mean GDR score of 11.02 among our participants signifies a noteworthy adherence to healthy dietary patterns. This increase not only reflects an improvement in participants' dietary behaviours but also suggests a closer alignment with global dietary recommendations. Such findings indicate a positive impact of the intervention on fostering healthier dietary habits within our study population, particularly when compared to dietary practices in neighbouring countries.

The findings regarding MDD-W provide valuable insights into the micronutrient adequacy of participants' diets before and after the intervention. In the pretest phase, 44.5% of participants were classified as having 'adequate' dietary diversity, indicating the consumption of a variety of food groups essential for meeting micronutrient needs. Following the intervention, this proportion increased significantly to 67.8%, reflecting a notable improvement in dietary diversity among the participants. The observed difference of 23.3% (95% CI, 15.89–30.63) between the pre-test and post-test MDD-W percentages emphasises the effectiveness of the intervention in promoting a more diverse and nutritious diet among participants. Although the observed difference was higher in our study, it is important to note that the MDD-W percentage obtained in our study was lower than that reported in previous studies conducted in the country (67.8% vs. 96.9%) [14]. This may be mainly due to differences in the sociodemographic characteristics of our population, or it could be attributable to the amount of cash received from the intervention being inadequate to access a balanced diet. Overall, MDD-W has been found to be very low in similar international studies where the population suffers from poverty [38].

Strengths and limitations
In acknowledging the strengths of this research, it is notable that the utilisation of multilingual questionnaires in both the Sinhala and Tamil languages facilitated

the inclusion of diverse ethnic groups across Sri Lanka. By including multiple strata within the population, such as households with specific demographic characteristics and health conditions, this study enhanced the representativeness of the sample. The use of stratified sampling ensures adequate representation from each subgroup, minimising bias and increasing the generalisability of the findings. While the use of stratified sampling ensured adequate representation from each subgroup, minimising bias, and increasing the generalisability of our findings, we did not calculate weighted averages for the analysis. Although this approach could have enhanced the robustness of our results, it is beyond the scope of the current study.

The study's reliance on validated tools for data collection, such as the Diet Quality Questionnaire (DQQ) [22] and the Food Security Questionnaire [23], enhances the reliability and validity of the data collected. Utilising both digital platforms and in-person sessions increases accessibility and effectiveness, catering to the varying preferences within the target population. Overall, these strengths underscore the methodological rigor, inclusivity, and comprehensiveness of the study, positioning it to generate reliable findings and effectively address the multifaceted health and nutritional needs of the community.

This study has some limitations. The single-group pre-post design, while enabling comparisons before and after the intervention, lacks a control group, limiting the ability to attribute observed changes solely to the intervention and potentially confounding results with external factors. The use of self-reported data collected via interviewer-administered questionnaires may be susceptible to social desirability and recall bias, particularly regarding dietary habits and food security status, impacting the reliability and validity of the findings. One limitation of this study was the potential difficulty in message accessibility for participants with no formal education or limited literacy skills. Although we ensured that the messages were simple and easy to understand using clear language and visuals where possible, the full accessibility of the messages may have been constrained. In cases where participants faced challenges in reading or understanding messages, family members or caregivers were encouraged to assist. However, reliance on such support may have affected the participants' direct engagement with the intervention content. Lastly, the relatively short duration of the intervention, spanning eight weeks, may not allow sufficient time for significant and sustainable changes, warranting longer follow-up periods to comprehensively assess the intervention's effectiveness over time. Additionally, we did not collect specific information on how financial aid was allocated to different household needs. Furthermore, we did not capture other concurrent low-income support programs (non-governmental) that were parallel to our intervention. These support programs may have influenced our findings. However, to our knowledge, no other government programs provide financial aid for nutritional improvements.

Conclusions and recommendations

In conclusion, this study has provided valuable insights into the effectiveness of cash transfers and subsequent mobile phone-based nutritional education interventions aimed at improving dietary diversity and food security among low-income families during a financial crisis in two selected districts of Sri Lanka. The results indicated significant improvements across various indicators, including reductions in food insecurity, enhancements in dietary diversity, and positive shifts in nutrition practices among participants. These findings suggest that targeted interventions focusing on promoting dietary diversity and addressing food insecurity can play a crucial role in enhancing the nutritional well-being of low-income families during times of economic hardships. Future research should explore the mechanisms underlying this reduction in food insecurity and evaluate the long-term sustainability of the effects of the intervention. Additionally, qualitative investigations may provide insights into participants' experiences and perceptions of the intervention, enhancing our understanding of its impact on food security outcomes. While the findings indicate positive outcomes in improving dietary diversity and food security in the study population, it is important to acknowledge that the single-group pre-post design, without a control group, limits the ability to attribute these changes solely to the intervention. External factors may have influenced the results. Future studies should consider incorporating a control group to strengthen the evidence and to provide clearer insights into the direct impact of similar interventions.

Additionally, we acknowledge that we did not capture other concurrent low-income support programs running in parallel with our intervention. These programs may have influenced our findings and should be considered when interpreting the results. Capturing data on concurrent support programs would provide a more comprehensive understanding of the factors that influence dietary diversity and food security. By considering these elements, researchers can better isolate the effects of specific interventions and contribute to more effective strategies for improving nutrition in low-income populations.

Abbreviations

NCD	Non-communicable diseases
MAMA	Mobile Alliance for Maternal Action
LMIC	Lower middle-income countries
DS	Divisional Secretariat
DQQ	Diet Quality Questionnaire
DD	Dietary Diversity
MDD	W-The Minimum Dietary Diversity for Women
GDR	Global Dietary Recommendations

Wijesinghe *et al. BMC Nutrition*   (2024) 10:150

Page 11 of 12

LKR   Sri Lankan Rupees
SMS   Short Messaging Service
HEOs   Health Education Officers
SPSS   Statistical Package for Social Sciences

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40795-024-00958-3.

Supplementary Material 1

Supplementary Material 2

Author contributions
Conceptualisation, M.S.D.W, A.S.Y; Methodology; M.S.D.W, B.M.I.G, U.G.K, N.A.K.A.I.N, A.S.Y, R.B, D.R.P and R.D.B; Software, M.S.D.W, N.A.K.A.I.N, U.G.K, A.S.Y; Validation; M.S.D.W, B.M.I.G, A.S.Y, R.D.B, D.R.P and R.B; Formal analysis, N.A.K.A.I.N, U.G.K, M.S.D.W; Investigation; A.S.Y, B.M.I.G, U.G.K, N.A.K.A.I.N and R.D.B; Resources, A.S.Y, D.R.P and R.B and R.D.B; Data curation; A.S.Y, U.G.K, N.A.K.A.I.N; Writing – original draft; M.S.D.W, B.M.I.G, U.G.K, N.A.K.A.I.N; Writing – review & editing, M.S.D.W, B.M.I.G, U.G.K, N.A.K.A.I.N, A.S.Y, D.R.P, R.D.B and R.B; Supervision, M.S.D.W, R.B; Project administration, M.S.D.W, R.B , A.S.Y and R.D.B. All the authors have read and agreed to the published version of the manuscript.

Data availability
The datasets used in the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
All methods of this study were performed in accordance with the ethical principles of the Declaration of Helsinki for medical research involving human subjects. Ethical clearance was obtained from the Postgraduate Institute of Medicine, University of Colombo, 160, Prof. Nandadasa Kodagoda Mw, Colombo 07, and Sri Lanka (ERC/PGIM/2022/183). Informed consent was obtained from all study participants.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
¹Health Promotion Bureau, No.02, Kynsey Road, Colombo 08, Sri Lanka
²SUN-Peoples Forum, Colombo, Sri Lanka
³United Nations, World Food Programme, Colombo, Sri Lanka

References
1. Mannar V, Micha R, Allemandi L, Afshin A, Baker P, Battersby J et al. 2020 global nutrition report: action on equity to end malnutrition. 89023; 2020. Report No.: 1916445276. https://globalnutritionreport.org/reports/2020-global-nutrition-report/. Accessed 20 April 2024.
2. Food and Agriculture Organization (FAO). The State of Food Security and Nutrition in the World 2022: Repurposing Food and Agricultural policies to make healthy diets more affordable. Rome: FAO; 2022.
3. World Bank. Updated estimates of the impact of COVID-19 on global poverty: turning the corner on the pandemic in 2021? Washington D.C.: World Bank Group; 2021.
4. Campbell CC. Food insecurity: a nutritional outcome or a predictor variable? J Nutr. 1991;121(3):408–15. https://doi.org/10.1093/jn/121.3.408. Accessed 27 April 2024.
5. WHO, Nutrition. [cited 2024 Apr 30]. Nutrition. https://www.who.int/health-topics/nutrition. Accessed 15 April 2024.
6. Family Health Bureau Ministry of Health Sri Lanka. Summary Report - Nutrition Month 2023 [Internet]. 2023 [cited 2024 Oct 3]. https://fhb.health.gov.lk/wp-content/uploads/2019/11/Nutrition-Month-2023-Report-English.pdf. Accessed 25 April 2024.
7. Department of Census and Statistics Sri Lanka. Demographic and Health Survey 2016 - Presentations [Internet]. 2023 [cited 2024 Oct 3]. http://www.statistics.gov.lk/Health/StaticalInformation/DHS. Accessed 8 May 2024.
8. Food and Agriculture Organization of the United Nations. Special Report – FAO/WFP Crop and Food Security Assessment Mission (CFSAM) to the Democratic Socialist Republic of Sri Lanka [Internet]. FAO, WFP. ; 2022 [cited 2024 May 17]. http://www.fao.org/documents/card/en/c/cc1886en. Accessed 16 April 2024.
9. Weerasekara PC, Withanachchi CR, Ginigaddara GAS, Ploeger A. Understanding dietary diversity, dietary practices and changes in food patterns in marginalised societies in Sri Lanka. Foods. 2020;9(11):1659. https://doi.org/10.3390/foods9111659. Accessed 27 April 2024.
10. World Health Organization (WHO). mHealth: New horizons for health through mobile technologies. Geneva: World Health Organization; 2011.
11. Mobile Alliance for Maternal Action (MAMA). Lessons Learned Brief [Internet]. [cited 2024 May 1]. https://mcsprogram.org/resource/mobile-alliance-maternal-action-mama-lessons-learned-brief/. Accessed 16 April 2024.
12. Ahsan A, Raihan A. Understanding mHealth impact among Aponjon (MAMA Bangladesh) subscribers through a phone survey in Bangladesh. In: Proceedings of the Sixth International Conference on Information and Communications Technologies and Development: Notes - Volume 2 [Internet]. New York, NY, USA: Association for Computing Machinery; 2013 [cited 2024 May 1]. pp. 1–4. (ICTD '13). https://doi.org/10.1145/2517899.2517920. Accessed 25 April 2024.
13. Acharya A, Cunningham K, Manandhar S, Shrestha N, Chen M, Weissman A. Exploring the Use of Mobile Health to Improve Community-Based Health and Nutrition Service Utilization in the hills of Nepal: qualitative study. J Med Internet Res. 2020;22(9):e17659. https://doi.org/10.2196/17659. Accessed 28 April 2024.
14. Peiris DR, Wijesinghe MSD, Gunawardana BMI, Weerasinghe WMPC, Rajapaksha RMNU, Rathnayake KM, et al. Mobile phone-based Nutrition Education Targeting pregnant and nursing mothers in Sri Lanka. Int J Environ Res Public Health. 2023;20(3):2324. https://doi.org/10.3390/ijerph20032324. Accessed 20 April 2024.
15. Czarniecka-Skubina E, Hamulka J, Gutkowska K. How can we increase the Nutrition-related knowledge in children aged 7–12 years: results of focus groups interviews with parents—Junior-Edu-Żywienie (JEŻ) Project. Nutrients. 2023;16(1):129. https://doi.org/10.3390/nu16010129. Accessed 30 April 2024.
16. Hall CS, Fottrell E, Wilkinson S, Byass P. Assessing the impact of mHealth interventions in low- and middle-income countries – what has been shown to work? Glob Health Action. 2014;7(1):25606. https://doi.org/10.2196/mhealth.8873. Accessed 6 May 2024.
17. McCarroll R, Eyles H, Ni Mhurchu C. Effectiveness of mobile health (mHealth) interventions for promoting healthy eating in adults: a systematic review. Prev Med. 2017;105:156–68. https://doi.org/10.1016/j.ypmed.2017.08.022. Accessed 8 May.
18. Information and Communication Technology agency of Sri Lanka - Brief of Scope of services Process Study and Business Process. Re - engineering solution for Divisional Secretariat (eDS) [Internet]. [cited 2022]. www.icta.lk. Accessed 10 October 2024.
19. Department of Samurdhi Development. - Dawn of New Era [Internet]. [cited 2022 Aug 10]. http://www.samurdhi.gov.lk/web/images/stories/publications/english/dawn_of_a_new_era.pdf. Accessed 08 October 2024.
20. Ministry of Social Empowerment and Welfare. - Samurdhi Act, No. 1 of 2013 [Internet]. [cited 2013]. [Internet]. [cited 2022 Aug 10]. Accessed 08 October 2024.

21. Lwanga SK, Lemeshow S, World Health Organization. Sample size determination in health studies: a practical manual. World Health Organization; 1991. https://iris.who.int/handle/10665/40062. Accessed 16 April 2024.

22. Global Diet Quality Project. - DQQ Tools [Internet]. [cited 2022 Oct 27]. https://www.globaldietquality.org/dqq. Accessed 20 April 2024.

23. USDA. 2012. [Begin Six-Item Food Security Module]. https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/survey-tools/#six. Accessed 28 April 2024.

24. Ruel MT. Operationalizing Dietary Diversity: a review of Measurement issues and Research priorities. J Nutr. 2003;133(11):S3911–26. https://doi.org/10.1093/jn/133.11.3911S. Accessed 8 May 2024.

25. Uyar BTM, Talsma EF, Herforth AW, Trijsburg LE, Vogliano C, Pastori G et al. The DQQ is a Valid Tool to Collect Population-Level Food Group Consumption Data: A Study Among Women in Ethiopia, Vietnam, and Solomon Islands. J Nutr. 2023;153(1):340–51. https://doi.org/10.1016/j.tjnut.2022.12.014. Accessed 28 April 2024.

26. Arimond M, Wiesmann D, Ramírez S, Levy T, Ma S, Zou Z, et al. Food group diversity and nutrient adequacy: dietary diversity as a proxy for micronutrient adequacy for different age and sex groups in Mexico and China. GAIN Discuss Pap. 2021;9. https://doi.org/10.36072/dp.9. Accessed 27 April 2024.

27. Development of a dichotomous indicator for population-level assessment of dietary diversity in women of reproductive age. Curr Dev Nutr. 2017;1(12):cdn-117. https://doi.org/10.3945/cdn.117.001701. Accessed 06 May 2024.

28. Food and Agriculture Organization of the United Nations. Minimum dietary diversity for women [Internet]. FAO. 2021 [cited 2024 May 17]. http://www.fao.org/documents/card/en/c/cb3434en. Accessed 30 April 2024.

29. Herforth A. Diet Quality Questionnaire (DQQ) Indicator Guide. 2022; https://www.dietquality.org/tools. Accessed 27 April 2024.

30. Herforth AW, Wiesmann D, Martínez-Steele E, Andrade G, Monteiro CA. Introducing a suite of low-burden diet quality indicators that reflect healthy diet patterns at population level. Curr Dev Nutr. 2020;4(12):nzaa168. https://doi.org/10.1093/cdn/nzaa168. Accessed 25 April 2024.

31. Frankenberger T, Peña-Montenegro A, Tilakaratna S, Velarde N, Eide WB. Rural poverty alleviation and nutrition: IFAD's evolving experiences. 1993.

32. Blumberg SJ, Bialostosky K, Hamilton WL, Briefel RR. The effectiveness of a short form of the Household Food Security Scale. Am J Public Health. 1999;89(8):1231–4. https://doi.org/10.2105/ajph.89.8.1231. Accessed 28 April 2024.

33. United States Department of Agriculture. U.S. Household Food Security Survey Module: Six-Item Short Form [Internet]. 2012. https://www.ers.usda.gov/media/8282/short2012.pdf. Accessed 6 May 2024.

34. Department of Census and Statistics [Internet]. [cited 2024 May 1]. http://www.statistics.gov.lk/Population/PopHouStat_Population#gsc.tab=0. Accessed 25 April 2024.

35. Department of Census and Statistics Sri Lanka. Literacy rate of population (age 10 years and above) by district and sex, 2021 [Internet]. 2021 [cited 2024 Oct 3]. http://www.statistics.gov.lk/Resource/en/GenderStatistics/Education/LiteracyRateOfPopulation-10YearsAndAbove-ByDistrictAndSex.pdf. Accessed 08 May 2024.

36. Behzadifar M, Student MB, Bs SA, Salmani MA, Ghoreishinia G, Falahi E, et al. Prevalence of Food Insecurity in Iran: a systematic review and Meta-analysis. Arch Iran Med. 2016;19(4):288–94. PMID: 27041526. Accessed 27 April 2024.

37. Global Diet Quality Project [Internet]. [cited 2024 May 13]. https://www.dietquality.org/indicators/gdr-score/map. Accessed 17 April 2024.

38. Adubra L, Savy M, Fortin S, Kameli Y, E Kodjo N, Fainke K, et al. The Minimum Dietary Diversity for women of Reproductive Age (MDD-W) Indicator is related to Household Food Insecurity and Farm Production Diversity: evidence from rural Mali. Curr Dev Nutr. 2019;3(3):nzz002. https://doi.org/10.1093/cdn/nzz002. Accessed 27 April 2024.

Publisher's note