

The effectiveness of a WeChat-based self-assessment with a tailored feedback report on improving complementary feeding and movement behaviour of children aged 6–20 months in rural China: a cluster randomized controlled trial



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Summary

Background Appropriate infant feeding and movement behaviour (i.e. physical activity, sedentary behaviour, sleep) play an important role in children's healthy development during the first two years of life. The popular Chinese social media app 'WeChat' has become a potential data collection and health promotion tool. We aimed to evaluate the effectiveness of a WeChat-based self-assessment with a tailored feedback report on improving complementary feeding practices and movement behaviour of children aged 6–20 months in rural China.

Methods We conducted a two-armed cluster randomized control trial in Datong County, Qinghai Province, China. There were 106 clusters from 257 villages allocated (1:1) to two groups: the feeding group, which received a complementary feeding recommendations feedback report; the movement behaviour group, which received movement behaviour recommendations feedback report. The feeding group acted as a control for the movement behaviour group and vice versa. Children aged 6–20 months and their primary caregivers were invited to be participants. WeChat was used to collect the data on outcomes and to deliver the interventions. Participants received the interventions by filling out the WeChat self-assessment questionnaire and reading tailored feedback reports at baseline, at the first 1-month follow-up and at the second 2-month follow-up. Outcome measures included changes in the prevalence of minimum dietary diversity (MDD), minimum meal frequency (MMF), minimum acceptable diet (MAD); and the proportion of children who met physical activity time (PAT), outdoor time (OT) and screen time (ST) recommendation between the two groups at the two follow-ups. This study is registered at Chinese Clinical Trial Registry-ChiCTR2200062529.

Findings Between September 28th and October 12th 2022, we recruited 1610 children in 106 clusters, of which 53 clusters (800 children) were randomized to the feeding group and 53 clusters (810 children) to the movement behaviour group. All caregivers of children completed questionnaires at three time points without loss to follow-up. From baseline to the second follow-up, the prevalence of MDD (OR: 1.62 [95% CI, 1.16–2.28; $p = 0.0058$]), MMF (OR: 1.45 [95% CI, 1.03–2.04; $p = 0.032$]) and MAD (OR: 1.51 [95% CI, 1.12–2.05; $p = 0.0081$]) in the feeding group were significantly higher than that in the movement behaviour group. The proportion of children who met PAT during the last 24 h at the second follow-up (OR: 2.22 [95% CI, 1.26–2.17; $p < 0.0001$]) and OT at the second follow-up (OR: 1.94 [95% CI, 1.49–2.54; $p < 0.0001$]) significantly improved in the movement behaviour group compared to the feeding group. Furthermore, ST in the movement behaviour group showed a significant increase only at the first follow-up (OR: 1.36 [95% CI, 1.02–1.82; $p = 0.036$]).

Interpretation WeChat-based self-assessment with tailored feedback was an effective channel to deliver feeding and movement behaviour recommendations in rural China in our study. This approach can be applied to change feeding practices of caregivers of young children alongside routine child health care in rural China.

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Research in context

Evidence before this study

Improvement of infant and young child feeding (IYCF) and movement behaviour via m-health in rural areas has seemed promising. On December 20th, 2022, we searched PubMed for publications reporting results from randomized controlled trials of mhealth intervention on IYCF and movement behaviour. We used the search terms “digital health”, “mhealth”, “new media”, “social media” and “infant and young child”, “infant feeding”, “breastfeeding”, “complementary feeding”, “movement behaviour”, “randomized controlled trial” without language restrictions. We identified 28 randomized controlled trials which examined the effectiveness of mhealth intervention for promoting IYCF, with only five trials focused on promoting complementary feeding. We are not aware of any these trials on evaluating the effectiveness of self-assessment with tailored feedback. Moreover, we did not find publications of mhealth intervention on movement behaviour for infant and young children.

Added value of this study

To our knowledge, this present study is the first cluster randomized controlled trials to evaluate the effectiveness of a WeChat-based self-assessment with tailored feedback to improve complementary feeding and movement behaviour for infants and young children. Our study showed that

WeChat-based self-assessment with tailored feeding feedback was more effective than that in control group at the second follow-up in improving minimum dietary diversity (73.1% vs. 62.8%, $p = 0.0058$), minimum meal frequency (80.9% vs. 75.2%, $p = 0.032$), and minimum acceptable diet (60.9% vs. 51.1%, $p = 0.0081$). Our study also showed the WeChat-based self-assessment with tailored movement behaviour feedback was more effective than that in control group in improving the proportion of children who met physical activity time (43.8% vs. 27.8%, $p < 0.0001$) and outdoor time (62.2% vs. 47.0%, $p < 0.0001$).

Implications of all the available evidence

Promoting appropriate IYCF and movement behaviours for infants and young children in China is greatly needed. As the most widely used social media app in China, WeChat has become a potential survey and health promotion tool in China. Evidence from this trial suggests that the WeChat-based self-assessment with tailored feedback was an effective channel to deliver feeding and movement behavior recommendations to caregivers thus to improve the complementary feeding practices and movement behaviours of infants and young children. This feasible and effective implementation strategy could be scaled up in rural China and other low-resource settings for child health promotion.

Introduction

The first 1000 days of life—from conception until 2 years of age—is the crucial period for building the foundations of optimal growth and development of the child, and contributes to long-term health outcomes.^{1,2} Especially the period of complementary feeding (6–24 months) is well recognized as one of the most critical times for preventing malnutrition.³ Promoting appropriate infants and young children feeding (IYCF) and movement behaviours (i.e. physical activity, sedentary behaviour, sleep) in this period improves early childhood growth and development. It also reduces the risk of chronic non-communicable diseases, such as diabetes and cardiovascular disease, in later life.^{3–5}

The World Health Organization (WHO) and the United Nations Children’s Fund (UNICEF) recommend exclusive breastfeeding for the first 6 months of life and then introducing complementary food timely, adequately, and appropriately.⁶ Furthermore, UNICEF released a package of indicators for assessing IYCF practices, including the minimum dietary diversity (MDD), minimum meal frequency (MMF), minimum acceptable diet (MAD) and consumption of iron-rich or iron-fortified foods (CIRIFF).⁷ During the past two

decades, the Chinese government has implemented various maternal and child health related policies and interventions to increase infant feeding, such as the national program “Basic Public Health Service”⁸ and China Nutrition Improvement Project on Children in Poor Areas (CNIPCPA).⁹ However, the complementary feeding practices are still suboptimal in rural China. The data from CNIPCPA in 2018 showed that the prevalence of MDD, MMF, and MAD were 58.5%, 51.6%, and 35.1% for breastfed children aged 6–23 months in rural China, respectively.⁹ Both introducing complementary food too early (42.4% for <6 months) and too late (9.5% for >8 months) were prevalent in China.¹⁰ Moreover, the consumption of animal-source foods among children aged 6–23 months varied from 38% to 64.9% in rural areas.¹¹ Our previous study in Qinghai indicated that the prevalence of MAD was nearly unchanged from 2012 to 2018, which remained around 20% at all four surveys.¹² Therefore, much effort is required to explore effective interventions to promote complementary feeding in rural China.

In addition, movement behaviours are crucial for healthy development of young children.¹³ Movement behaviour consists of physical activity, sleep, and

sedentary behaviour. Adequate physical activity, sleep and limited screen time promote fundamental motor skills and health of young children. On the contrary, insufficient physical activity and excessive screen time will result in overweight.^{13–15} Consequently, a healthy balance of movement behaviour for infants and young children is recommended. In 2019, the WHO published “Guidelines on Physical Activity, Sedentary Behaviour and Sleep for Children under 5 Years of Age”, which provides recommendations on the amount of time per day that children under 5 years old should spend being physically active or sleeping for their health and well-being.¹⁶ Based on the WHO guidelines, China also issued a Physical Activity Guideline for all ages in 2021.¹⁷ For effective public health and surveillance, it is important to document the proportion of young children meeting these guidelines.¹⁴ However, there are no representative national data and interventional trials on movement behaviours for children under 2 years old in China, and current research is mainly focused on preschool children and teenagers. Therefore, it is necessary to conduct surveys to collect data on movement behaviours for children under 2 years old. Exploring effective ways to deliver the recommendations to promote appropriate movement behaviour is also greatly needed.

Self-tracking feedback helps convey data and affects people’s attitudes and behaviours.¹⁸ There is evidence that tailored interventions have resulted in more improvement over time than generic information for multiple health behaviours, such as dietary behaviours, sitting time and physical activity. However, almost all interventions in studies were delivered by means of computer-tailored letters, pamphlets, or brochures.^{19–21} With the widespread use of smartphones, mobile health technologies can contribute to positive and sustainable changes.^{22,23} As the most widely used social media app in China, WeChat has become a potential survey and health promotion tool in China.^{24–26} The WeChat mini program ‘Sojump’ is the largest free professional online survey platform in China. Our previous studies showed that WeChat-based self-administered data collection had good agreement compared to the interviewer-administered method and can achieve a high response rate for collecting complementary feeding data in rural China.^{27,28} The WeChat mini program can also provide participants with a tailored feedback report after completing self-assessment questionnaires, which could be an innovative way to deliver health interventions. However, no studies have combined both WeChat self-assessment data collection and a tailored feedback intervention to promote appropriate complementary feeding and movement behaviours. We aimed to evaluate the effectiveness of a WeChat-based self-assessment with a tailored feedback report on improving complementary feeding and movement behaviour of children aged 6–20 months in rural China.

Method

Study design and participants

This two-armed cluster randomized mutually controlled trial was carried out in 257 villages in Datong County, Qinghai Province, China between September 28th and December 4th 2022. Eligible individuals for this trial were infants and young children aged 6–20 months old and their primary caregivers who were able to read in Mandarin, used WeChat, and had access to the Internet. Exclusion criteria were children diagnosed with structural or genetic birth defects, such as neural tube defects, congenital heart disease, any inherited metabolic diseases, etc., and caregivers who refused to provide their phone number or WeChat account or were unavailable for follow up. Before the trial, we obtained an original list with names of all children aged 4–18 months in rural areas in July 2022 through the local routine health information system of the county, which included information on county, township, and village; child’s name, date of birth, gender; and mothers’ telephone number. We asked village doctors to cross-check the name list and add information on primary caregivers and whether the village doctor added the primary caregiver on WeChat as a ‘friend’ contact,²⁸ and we got the name list for randomization.

Randomization and masking

The cluster unit was based on villages. A village with at least 16 children was regarded as a cluster and we randomly selected 16 eligible children in the village as the participants. We aggregated several small villages (<16 children) nearby to form clusters. Clusters were assigned (1:1) to either the feeding group (receiving complementary feeding intervention and acted as the control of movement behaviour group) or the movement behaviour group (receiving movement behaviour intervention and acted as the control of the feeding group). Randomization schedules were generated with SPSS software. One research staff member (XTW) assigned clusters to the feeding group or the movement behaviour group. Due to the nature of the cluster design and intervention, the research staff, village doctors delivering WeChat questionnaires and caregivers were aware of group allocation.

The trial received ethics approval from the Ethical Committee of the Capital Institute of Pediatrics in Beijing. Participating caregivers read the electronic informed consent in the WeChat questionnaire, clicked “Agree to participate” and provided an electronic signature before they answered the questions.

Procedures

The interventions in this trial were complementary feeding recommendations for the feeding group and movement behaviour recommendations for the movement behaviour group. Complementary feeding recommendations included the following: introduction of

complementary food at six months, continued breastfeeding up to 2 years or beyond; minimum dietary diversity (eating at least five of eight food groups every day); food texture and frequency for different age groups; importance of the introduction of animal source food; micronutrient supplement. The movement behaviour intervention consisted of knowledge and behaviour recommendations on the following: at least 120 min of physical activities for infants aged 6–11 months and 180 min for young children aged 12–23 months; at least 60 min of outdoor time for young children aged 12–23 months; less than 1 h of physical restraint; recommended sleeping time for different age groups and no screen time for children younger than 2 years. All the interventions were developed based on the WHO recommendations for IYCF, or published literature and guidelines on physical activity, sedentary behaviour and sleep for children under the age of 5.^{6,7,16,17}

We used a WeChat min-program named “Sojump” to collect the data of outcomes and deliver interventions. Sojump is a professional online survey platform and widely used in China.^{27,28} We set the study questionnaires up on Sojump and obtained a Quick Response (QR) code for the feeding group and a QR code for movement behaviour group, both of which were used as a link to the questionnaire. Participants in both groups scanned the QR code using their WeChat app and then filled in the questionnaire online. When they completed and submitted the questionnaire, they received the intervention, which was a tailored feedback report based on their answers, consisting of total scores for all questions, personal feeding or movement behaviour problems and corresponding recommendations. Furthermore, the recommendations were also shown in pictures and videos to help caregivers get a better understanding (Supplementary Fig. S1). Although both groups completed the same questionnaires, the intervention of feedback reports were different. Caregivers in the feeding group only received feedback reports based on feeding questions in the questionnaire, and caregivers in the movement behaviour group only received the intervention of feedback reports based on movement behaviour questions.

The feeding part of the questionnaire was developed based on the adapted WHO Maternal, Newborn and Child Health Household Survey (MNCHHS) (unpublished, 2009) and “Indicators for assessing infant and young child feeding practices” (WHO & UNICEF)⁷ and has been proven to be in good agreement with interviewer-administered method in our previous study.^{27,28} In addition, we collected the frequency of seven groups of complementary food during the last month. The movement behaviour part was developed based on the WHO guideline on physical activity, sedentary behaviour and sleep for children under 5 years of age. This was used to collect data on physical

activity time, outdoor time, sleep duration, physical restraint, and screen time during the last 24 h and during the last 2 weeks. Moreover, there were 3 multiple-choice questions on caregivers’ knowledge of exclusive breastfeeding duration, complementary food introduction time and continues breastfeeding duration; and 5 multiple-choice questions on caregivers’ knowledge of physical activity time, outdoor time, sleep duration, physical restraint, and screen time. Furthermore, we added 8 questions in the questionnaire at the second follow, including 2 questions for information source on complementary feeding and movement behaviour, and 6 questions for evaluating the WeChat self-assessment tool.

The WeChat self-assessment questionnaires and intervention of feedback reports were pre-tested in two communities in Datong County in August 2022. A total of 26 caregivers were invited to fill in the WeChat self-assessment questionnaire: 10 caregivers were provided with feeding intervention feedback reports and 16 caregivers were provided with movement behaviour intervention feedback reports. After caregivers completed the questionnaire and reviewed the feedback report, community health workers interviewed each of them and collected their feedback and suggestions on the questionnaire and feedback report of intervention. All of the caregivers said they could understand the questions and had no suggestions on questionnaire and feedback report modification. Four caregivers reported that the feedback was timely, professional, worth learning and could be a guide for feeding practices.

The WeChat self-assessment questionnaire was distributed through the 3-tier health care system (county-township-village), which was in line with our previous study.²⁸ We first invited a county coordinator and all township coordinators in Datong County into a WeChat group and trained them the study procedures. We sent the QR code of the feeding group and QR code of the movement behaviour group to township coordinators, who then sent them to village doctors according to the group allocation. Village doctors who added participants as WeChat contacts sent the QR code to participants via WeChat. Participants received interventions by filling out the WeChat questionnaires and reading tailored feedback reports at baseline (September 28th–October 12th), the first follow-up at 1 month (October 28th–November 3rd) and the second follow-up at 2 months (November 28th–December 4th 2022) after baseline. After participants completed and submitted the questionnaires, data were uploaded into Sojump system. Caregivers whose data were not found in Sojump platform after 1 week received reminders from village doctors.

Outcomes

The primary outcome for complementary feeding measure was proportion of minimum dietary diversity

(MDD), minimum meal frequency (MMF), minimum acceptable diet (MAD), consumption of iron-rich or fortified foods (CIRIFF), consumption of iron-rich foods (CIRF), and continued breastfeeding at 12–23 months (CBF) at baseline, 1 month follow-up and 2 months follow-up in both groups [Panel 1]. The primary outcome for movement behaviour measure was proportion of children who met the recommendation of physical activity time (PAT), outdoor time (OT), physical restraint (PR), sleep duration (SD) and screen time (ST) during the last 24 h and during the last two weeks.

The secondary outcome for the complementary feeding measure was the frequency of seven groups of complementary food during the last month. We assumed high food frequency intake as that a child ate the food in the food group at least 3 times per week. We also compared the change of caregivers' knowledge on feeding and movement behaviour in both groups.

The third outcome was caregivers' information source on complementary feeding and movement behaviour at the second follow-up. Moreover, evaluation of self-assessment tool by caregivers at the second follow-up was showed, which included number of times questionnaire filled out, usefulness of self-assessment tool, whether read the feedback report, usefulness of feedback report, whether watched the health education video for the feedback report, and usefulness of the health education video for the feedback report.

Data management and statistical analysis

The sample size of this trial was calculated based on our previous studies, assuming the intervention effect could increase MAD at 10% with an available 35% of prevalence.⁹ With a 5% significance level and 80% power, an intraclass correlation coefficient of 0.05, we needed 43 clusters and 645 caregivers per group. Allowing for up to 25% loss to follow-up, we aimed to recruit at least 807 children per group, therefore, we needed at least 10 more clusters per group.

One research staff member (XTW) was in charge of database maintenance and management. Data collected via Sojump were secured first, and then uploaded into a database. The initial database was stored in our Sojump account, which was accessible by a unique password. After data cleaning, the database was converted into Microsoft Excel sheets.

Data were analyzed using SAS 9.4 software (SAS Institute, Cary, NC). We used the medians and interquartile ranges (IQRs) to describe continuous variables, and number and proportions to describe categorical variables. The homogeneity in baseline characteristics between feeding group and movement behaviour group was estimated using Wilcoxon rank sum test for continuous variables for nonparametric continuous variables and χ^2 test for categorical variables. To determine the effect size of the intervention,

we used generalized linear mixed models that included cluster-level random intercepts to account for the correlation due to clustering of children within villages, which was the level at which the intervention was assigned. In these models, we adjusted for important factors associated with infant feeding practices and physical activity, including baseline values of the outcome measures, children's age, sex, and primary caregivers. Adjusted odds ratios (OR) and 95% confidence interval (CI) were reported. Statistical significance was determined by a 2-sided $p < 0.05$. This trial was registered at Chinese Clinical Trial Registry-ChiCTR2200062529.

Role of the funding source

The funders of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all data in the study and had final responsibility for the decision to submit for publication.

Results

There were 1844 children from 289 villages on the initial name list in Datong County, and 32 villages and children in these villages were excluded because caregivers had no WeChat (2) or refused to provide their WeChat number (57). The remaining 1785 children came from 257 villages, with the number of eligible children in each village varying greatly from 1 to 56. Twenty-three clusters came from 23 large villages (≥ 16 children) with 175 children excluded, and 83 clusters were formed by aggregating several small villages (< 16 children) nearby, with each cluster consisting of 14–16 children. Finally, 106 clusters with 1610 participants were randomized into feeding group (53 clusters, 800 children) and movement behaviour group (53 clusters, 810 children) at a 1:1 ratio. The trial started in September 2022 when children were aged 6–20 months. We sent the final lists of children to village doctors and asked them to recruit participants. Nine children on the lists (3 from feeding group, 6 from movement behaviour group) were replaced by those in the same village because they moved out with parents (4), they died (2), the guardian died (1), or they were duplicates on the original lists (2). All participants completed questionnaires three times without loss to follow-up (Fig. 1).

Table 1 describes the baseline characteristics of children and their primary caregivers. A total of 1610 children were recruited, with 36% aged 6–11 months and 64% aged 12–20 months. The median age of all primary caregivers was 29 years old and nearly 80% of them were mothers. More than 80% of primary caregivers attended junior high school or above and 43.9% did housework as their occupation, followed by farmers (30.7%) and herdsmen (14.2%). The two groups were

Panel 1: Outcome measurement.**Feeding assessment**

The primary outcomes for feeding assessment were infant and young child feeding (IYCF) indicators proposed by the WHO & UNICEF:

- 1. Minimum dietary diversity 6–23 months (MDD):** Percentage of children 6–23 months of age who consumed foods and beverages from at least five out of eight defined food groups during the previous day. The eight food groups used for tabulation of this indicator were: 1) breast milk; 2) grains, roots, tubers and plantains; 3) pulses (beans, peas, lentils), nuts and seeds; 4) dairy products (milk, infant formula, yogurt, cheese); 5) flesh foods (meat, fish, poultry, organ meats); 6) eggs; 7) vitamin A rich fruits and vegetables; and 8) other fruits and vegetables.
- 2. Minimum meal frequency 6–23 months (MMF):** Percentage of children 6–23 months of age who consumed solid, semi-solid or soft foods (but also including milk feeds for non-breastfed children) at least the minimum number of times during the previous day. The minimum number of times was defined as:
 - two feedings of solid, semi-solid or soft foods for breastfed infants aged 6–8 months;
 - three feedings of solid, semi-solid or soft foods for breastfed children aged 9–23 months;
 - four feedings of solid, semi-solid or soft foods or milk feeds for non-breastfed children aged 6–23 months whereby at least one of the four feeds must be a solid, semi-solid or soft feed.
- 3. Minimum acceptable diet 6–23 months (MAD):** Percentage of children 6–23 months of age who consumed a minimum acceptable diet during the previous day. The minimum acceptable diet was defined as:
 - for breastfed children: receiving at least the minimum dietary diversity and minimum meal frequency for their age during the previous day;
 - for non-breastfed children: receiving at least the minimum dietary diversity and minimum meal frequency for their age during the previous day as well as at least two milk feeds.
- 4. Consumption of iron-rich or iron-fortified foods (CIRIFF):** Percentage of children aged 6–23 months who received iron-rich food or iron fortified food that was specially designed for infants and young children, or that was fortified in the home.
- 5. Consumption of iron-rich foods (CIRF):** Percentage of children aged 6–23 months who received iron-rich or fortified foods.
- 6. Continued breastfeeding at 12–23 months (CBF):** Percentage of children 12–23 months of age who were fed breast milk during the previous day.

The secondary outcomes for feeding assessment were the frequency of seven groups of complementary food during the last month and caregivers' feeding knowledge.

Food frequency for last month: Percentage of children aged 6–23 months who ate seven food groups more than 3 times per week. The seven food groups are: 1) grains, roots, tubers and plantains; 2) vitamin-A rich fruits and vegetables; 3) other fruits and vegetables; 4) flesh foods; 5) eggs; 6) pulses (beans, peas, lentils), nuts and seeds; 7) dairy products (yogurts or cheese).

Caregivers' feeding knowledge: Caregivers know about exclusive breastfeeding for up to 6 months; caregivers know about starting complementary food at 6 months; caregivers know about continued breastfeeding for 2 years or beyond.

Movement behaviour assessment

The primary outcomes for movement behaviour assessment were indicators based on the WHO recommendations.

- 1. Physical activity time (PAT):** Percentage of children aged 6–23 months whose physical activity time met the recommendation during previous day and two weeks.
 - For children aged 6–11 months: spend at least 120 min in various types of physical activity per day.
 - For children aged 12–23 months: spend at least 180 min in various types of physical activity per day.
- 2. Outdoor time (OT):** Percentage of children aged 6–23 months whose outdoor time met the recommendation during previous day and two weeks.
 - For children aged 6–11 months: outdoor activity at least once a day.
 - For children aged 12–23 months: spend at least 60 min outdoor per day.
- 3. Physical restraint (PR):** Percentage of children aged 6–23 months who were not restrained for more than 1 h at a time during previous day and two weeks (e.g. prams/strollers, highchairs or strapped on a caregiver's back) or sit for extended periods of time.
- 4. Sleep duration (SD):** Percentage of children aged 6–23 months whose sleep duration met the recommendations during previous day and two weeks.
 - For children aged 6–11 months: have 12–16 h of good quality sleep, including naps.
 - For children aged 12–23 months: have 11–14 h of good quality sleep, including naps.
- 5. Screen time (ST):** Percentage of children aged 6–23 months whose screen time met the recommendations during previous day and two weeks. For children under 2-year old, screen time (such as watching TV or videos, playing computer games) is not recommended.

The secondary outcomes for movement behaviour assessment were **caregivers' knowledge on movement behaviours** which indicated that caregivers knew recommendations of corresponding age groups on PAT, OT, PR, SD and ST.

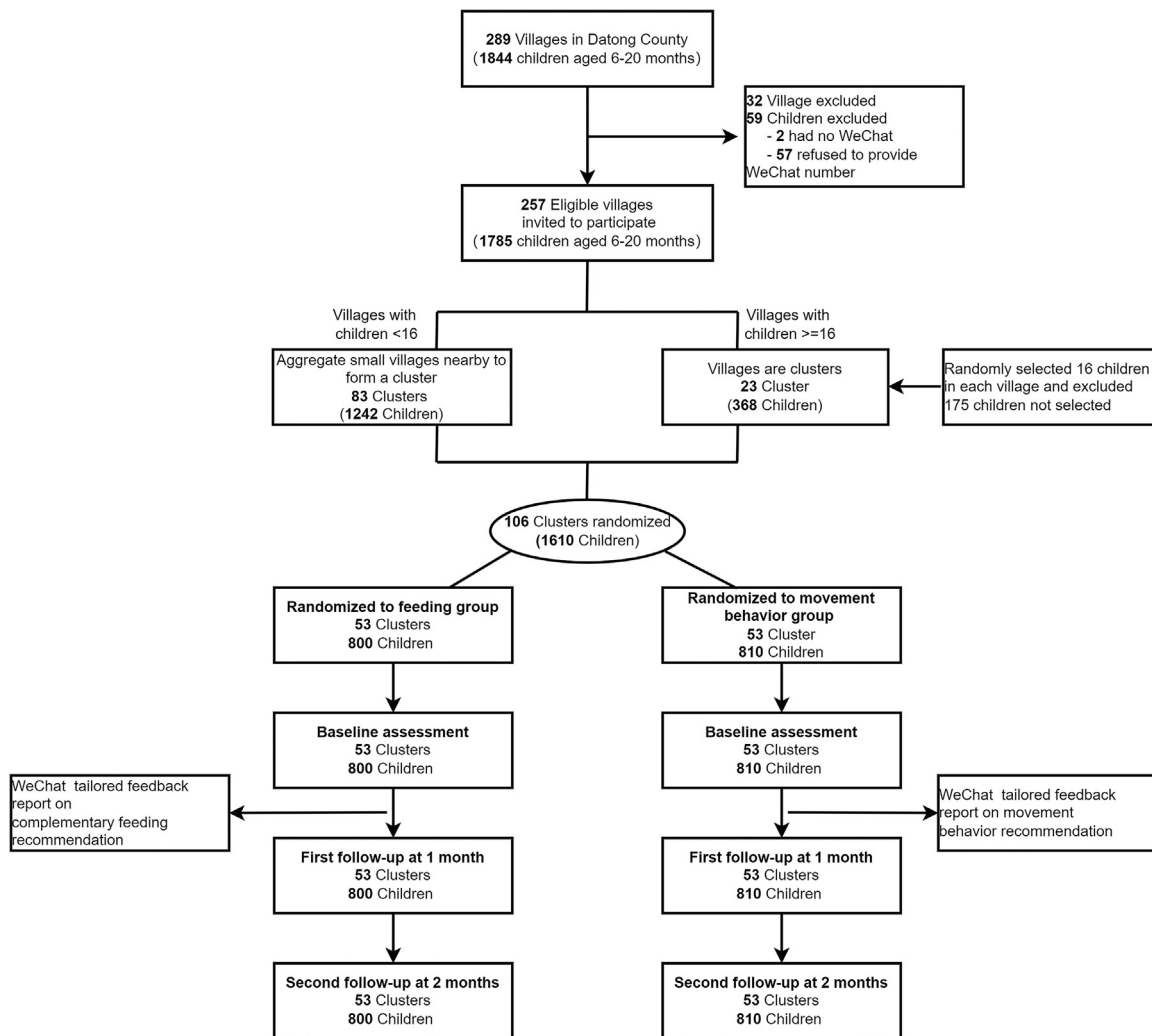


Fig. 1: Trial profile.

well balanced in most parameters except for education; more caregivers attended junior high school or above in the feeding group.

Table 2 shows the groups under comparison for assessing intervention effects on complementary feeding outcomes. In general, complementary feeding practices in the last 24 h, food frequencies in the last month and feeding knowledge increased with time in both groups. However, CBF slightly decreased in the feeding group from 20.7% at baseline to 18.3% at the first follow-up and dropped in the control group from 20.3% at baseline to 15.4% at the second follow-up. Knowing that complementary food needs to start at 6 months decreased from 55.3% at baseline to 48% at the second follow-up in the control group. At the first follow-up, four indicators for feeding practices (MDD [OR: 1.44; 95% CI, 1.08–1.91], MAD [OR: 1.32; 95% CI, 1.01–1.71], CIRIFF [OR: 1.63; 95% CI, 1.12–2.36] and

CIRF [OR: 1.36; 95% CI, 1.02–1.83]) and feeding knowledge of knowing continued breastfeeding duration [OR, 3.42; 95% CI, 2.28–5.11] improved in the feeding group compared with the control group. However, MMF, CBF and frequencies of all seven groups did not differ between 2 groups. At the second follow-up, all six indicators of feeding practice in the feeding group were significantly higher than in the control group (MDD [OR: 1.62; 95% CI, 1.16–2.28], MMF [OR: 1.45; 95% CI, 1.03–2.04], MAD [OR: 1.51; 95% CI, 1.12–2.05], CIRIFF [OR: 1.61; 95% CI, 1.06–2.43] and CIRF [OR: 1.43; 95% CI, 1.02–2.01]), CBF [OR: 1.64; 95% CI, 1.06–2.53]). Furthermore, the high consumption frequency of flesh food [OR: 1.42; 95% CI, 1.03–1.95], eggs [OR: 1.40; 95% CI, 1.01–1.92] and pulses [OR, 1.59; 95% CI, 1.15–1.92] in the feeding group were significantly increased compared to the control group. All three indicators of feeding knowledge increased significantly

	Feeding group (N = 800) n (%)	Movement behaviour group (N = 810) n (%)	Total (N = 1610) n (%)	p value
Children				
Sex				0.14
Male	392 (49.0)	427 (52.7)	819 (50.9)	
Female	408 (51.0)	383 (47.3)	791 (49.1)	
Age in months				0.31
6–11	297 (37.1)	283 (34.9)	580 (36.0)	
12–20	503 (62.9)	527 (65.1)	1030 (64.0)	
Primary caregivers				
Relationship				0.12
Mother	655 (81.9)	628 (77.5)	128 (79.7)	
Father	46 (5.8)	48 (5.9)	94 (5.8)	
Grandparents	85 (10.6)	114 (14.1)	199 (12.4)	
Others	14 (1.7)	20 (2.5)	34 (2.1)	
Age in years (median (IQRs))	28 (25, 33)	29 (24, 34)	29 (25, 34)	0.45
Education				0.0004
Primary school or below	133 (16.6)	180 (22.2)	313 (19.4)	
Junior high school	475 (59.4)	496 (61.3)	971 (60.3)	
Senior high school	111 (13.9)	82 (10.1)	193 (12.0)	
College or above	81 (10.1)	52 (6.4)	133 (8.3)	
Occupation				0.044
Housework	340 (42.5)	367 (45.4)	707 (43.9)	
Farmer	237 (29.6)	257 (31.7)	494 (30.7)	
Herdsman	133 (16.6)	95 (11.7)	228 (14.2)	
Other	90 (11.3)	91 (11.2)	181 (11.2)	

Table 1: Baseline characteristics of children and primary caregivers.

between groups with differences of 10–26 percent points and adjusted OR of 1.53–3.87.

Table 3 shows the intervention effects on movement behaviour outcomes. For movement behaviour practice, PAT during the last 24 h at the first follow-up (OR: 1.66 [95% CI, 1.26–2.17]) and at the second follow-up (OR: 2.22 [95% CI, 1.26–2.17]), and OT at the first follow-up (OR: 1.38 [95% CI, 1.05–1.81]) and at the second follow-up (OR: 1.94 [95% CI, 1.49–2.54]) significantly improved in the movement behaviour group for both follow-ups, as well as the indicators during the last two weeks. The screen time indicator showed a significant increase only at the first follow-up (OR: 1.36; 95% CI, 1.02–1.82), whereas PR and SD had no differences between groups in both follow-ups. For movement behaviour knowledge, PAT and OT were significantly improved in the movement behaviour group than in the control group in both follow-ups with differences of 9–19 percent points and adjusted OR of 1.56–2.35, whereas PR, SD and ST showed no difference between groups at both follow-ups.

Fig. 2 shows the sources of complementary feeding and movement behaviour information through which mothers received. In total, 1215 (75.5%) and 1143 (70.1%) caregivers reported that they ever received

information on complementary feeding or movement behaviour at the second follow-up, respectively. Nearly 60% of caregivers received information from health facilities, followed by friends and relatives (16%), new media such as WeChat and Baidu (14%, 12%) and traditional media such as TV, newspapers and books (7%).

Caregivers' evaluation of the self-assessment tool indicated that around 85% of them filled out the questionnaires at least 3 times and 93.4% believed that the assessment was very useful or useful. More than 90% of the caregivers read the feedback report and 96.8% of them thought that feedback report was very useful or useful. In addition, nearly 80% of caregivers watched the health education video and 98.5% of them believed that the video was very useful or useful (Table 4).

Discussion

This large cluster randomized controlled trial showed that a WeChat-based self-assessment with a tailored feedback intervention effectively improved complementary feeding practices and movement behaviours of children aged 6–20 months in rural China. Compared with the control group, key IYCF indicators of MDD, MMF, MAD and CIRIFF were significantly improved at the second follow-up in the feeding group, and the proportion of children who met physical activity guideline and outdoor time guideline showed significant improvement at both follow-ups in the movement behaviour group. The intervention also improved caregivers' knowledge on complementary feeding practices and movement behaviours.

The intervention in this cluster randomized controlled trial was novel in its combination of the WeChat-based self-assessment data collection and a tailored feedback intervention to promote caregivers' engagement. Caregivers received personalized feedback on complementary feeding or movement behaviour based on their answers in the self-assessment questionnaire, and the monthly repeated intervention was positively associated with changes in feeding practices and movement behaviours over time. This suggested that this WeChat-based individually tailored intervention was acceptable and useful for most primary caregivers in rural China, who could promptly understand their child's feeding and movement behaviours problems and continuously promote behavioural changes.

Evidence has showed that tailored interventions could improve multiple health behaviours^{19–21}; however, no studies delivered tailored feedback through mobile health. With the development of information technology and social media, smartphones have become new channels for health promotion.^{29–31} To our knowledge, this study is the first tailored feedback intervention study based on the smartphone app WeChat. As the most widely used app in China, WeChat-based tailored

	Baseline		First follow-up				p value	Second follow-up			
	Intervention group (N = 800) n (%)	Control group (N = 810) n (%)	Intervention group (N = 800) n (%)	Control group (N = 810) n (%)	Intervention vs. control adjusted OR (95% CI) ^a	Intervention group (N = 800) n (%)		Control group (N = 810) n (%)	Intervention vs. control adjusted OR (95% CI) ^a	p value	
Feeding practice for last 24 h											
Minimum dietary diversity (MDD)	374 (46.8)	359 (44.3)	507 (63.4)	445 (54.9)	1.44 (1.08, 1.91)	0.015	585 (73.1)	509 (62.8)	1.62 (1.16, 2.28)	0.0058	
Minimum meal frequency (MMF)	559 (69.9)	579 (71.5)	623 (77.9)	615 (75.9)	1.15 (0.83, 1.60)	0.39	647 (80.9)	609 (75.2)	1.45 (1.03, 2.04)	0.032	
Minimum acceptable diet (MAD)	282 (35.3)	275 (34.0)	417 (52.1)	368 (45.4)	1.32 (1.01, 1.71)	0.040	487 (60.9)	414 (51.1)	1.51 (1.12, 2.05)	0.0081	
Consumption of iron-rich or iron-fortified foods (CIRIFF)	621 (77.6)	612 (75.6)	669 (87.4)	656 (81.0)	1.63 (1.12, 2.36)	0.011	728 (91.0)	696 (85.9)	1.61 (1.06, 2.43)	0.025	
Consumption of iron-rich foods (CIRF)	391 (48.9)	386 (47.7)	497 (62.1)	450 (55.6)	1.36 (1.02, 1.83)	0.039	573 (71.6)	523 (64.6)	1.43 (1.02, 2.01)	0.040	
Continued breastfeeding at 12–23 months (CBF) ^b	105 (20.7)	107 (20.3)	92 (18.3)	108 (20.5)	0.81 (0.52, 1.26)	0.34	109 (21.5)	81 (15.4)	1.64 (1.06, 2.53)		
Food frequency for last month											
Grains, roots, tubers and plantains	261 (32.6)	240 (29.6)	304 (38.0)	327 (40.4)	0.87 (0.65, 1.18)	0.38	354 (44.3)	342 (42.2)	1.06 (0.75, 1.49)	0.75	
Vitamin-A rich fruits and vegetables	314 (39.3)	261 (32.2)	365 (45.6)	356 (43.9)	1.03 (0.77, 1.37)	0.86	462 (53.3)	367 (45.3)	1.33 (0.97, 1.83)	0.076	
Other fruits and vegetables	328 (41.0)	282 (34.8)	383 (47.9)	344 (42.5)	1.19 (0.92, 1.54)	0.18	427 (53.4)	372 (45.9)	1.29 (0.96, 1.74)	0.096	
Flesh foods	182 (22.8)	154 (19.0)	232 (29.0)	207 (25.6)	1.15 (0.85, 1.55)	0.38	299 (37.4)	236 (29.1)	1.42 (1.03, 1.95)	0.032	
Eggs	241 (30.1)	203 (25.1)	310 (38.8)	264 (32.6)	1.27 (0.96, 1.68)	0.096	358 (44.8)	294 (36.3)	1.40 (1.01, 1.92)	0.041	
Pulses (beans, peats, lentils), nuts and seeds	167 (20.9)	160 (19.8)	215 (26.9)	194 (23.9)	1.14 (0.86, 1.56)	0.41	313 (39.1)	230 (28.4)	1.59 (1.15, 2.19)	0.0053	
Dairy products (yogurts or cheese)	344 (43.0)	298 (36.8)	374 (46.8)	343 (42.4)	1.15 (0.88, 1.50)	0.32	401 (50.1)	352 (43.5)	1.27 (0.94, 1.71)	0.12	
Feeding knowledge (caregivers know)											
Exclusive breastfeeding up to 6 months	328 (41.0)	291 (35.9)	391 (48.9)	336 (41.5)	1.32 (0.99, 1.74)	0.057	449 (56.1)	370 (45.7)	1.53 (1.10, 2.12)	0.012	
Starting complementary food at 6 months	451 (56.4)	448 (55.3)	457 (57.1)	446 (55.1)	1.06 (0.81, 1.39)	0.66	501 (62.6)	389 (48.0)	1.83 (1.38, 2.43)	<0.0001	
Continued breastfeeding for 2 years or beyond	149 (18.6)	60 (7.4)	303 (37.9)	120 (14.8)	3.42 (2.28, 5.11)	<0.0001	346 (43.3)	140 (17.3)	3.87 (2.48, 6.04)	<0.0001	

^aGeneralized linear mixed models allowing for the cluster effect were used to analyze outcomes, with adjustment for baseline values of the outcome measures, children's age, sex, and primary caregivers.
^bDenominator for this indicator is children aged 12–23 months, 506 in intervention group and 527 in control group.

Table 2: Intervention effects on feeding outcomes (feeding group as intervention; movement behaviour group as control).

feedback intervention may render opportunities for scaling up the IYCF interventions in rural China, especially during the outbreak of COVID-19 when health worker could not access to caregivers and provide face-to-face IYCF counselling and health education for caregivers. Furthermore, it is well known that maternal literacy plays an important role for the use of mobile phone-based technologies.³² In our cluster randomized controlled trial, nearly 80% of primary caregivers were mothers and more than 80% of primary caregivers attended junior high school, which allows them to use this kind of intervention, as they could easily access, understand, and apply the information during their daily child care. It was reported that the literacy rate in China reached 99.83% in 2021,³³ thus the intervention could potentially be utilized by most caregivers in China.

Obesity has become a major public health issue in China.³⁴ Achieving adequate physical activity and sleep, while minimizing sedentary screen-time is important for young children's healthy development.³⁵ As far as we know, this is the first study assessing compliance with WHO Movement Guidelines for Chinese children aged 6–20 months and conducted intervention to promote movement behaviours in China. In this study, more

than half of children met outdoor time, sleep duration, sedentary behaviour and screen time guidelines in both group at the baseline; however, only around 20% children in both groups met physical activity guidelines, which was much lower than that in Australia.^{14,15} After two months of interventions, 43.8% children in the movement behaviour group met the physical activity guideline at the second follow-up, which was significantly higher than that (27.8%) in the control group (OR = 2.22). For the outdoor time, the proportion of children who met the guideline decreased from 59.8% to 47.0% in the control group and increased from 58.9% to 62.2% in the intervention group, which indicated our intervention could help increase outdoor time. In addition, the proportion of children who had no screen time maintained 73% in the movement behaviour group in the two follow-ups, while decreased from 74.9% to 68.5% in the control group, which also indicated our intervention could decrease screen time.

Although WeChat-based self-assessment with tailored feedback in our study was an effective channel to deliver feeding and movement behaviour information, multi-channel interventions are still needed in rural China. The results of our cluster randomized controlled trial indicated only a 5–10 percent points

	Baseline		First follow-up		Intervention vs. control adjusted OR (95% CI) ^a	p value	Second follow-up		Intervention vs. control adjusted OR (95% CI) ^a	p value
	Intervention group (N = 810) n (%)	Control group (N = 800) n (%)	Intervention group (N = 810) n (%)	Control group (N = 800) n (%)			Intervention group (N = 810) n (%)	Control group (N = 800) n (%)		
Movement behaviour practice for last 24 h										
Physical activity time (PAT)	174 (21.5)	184 (23.0)	316 (39.0)	234 (29.5)	1.66 (1.26, 2.17)	<0.0001	355 (43.8)	222 (27.8)	2.22 (1.68, 2.92)	<0.0001
Outdoor time (OT)	477 (58.9)	478 (59.8)	512 (63.2)	455 (56.9)	1.38 (1.05, 1.81)	0.021	504 (62.2)	376 (47.0)	1.94 (1.49, 2.54)	<0.0001
Physical restraint (PR)	635 (78.4)	629 (78.6)	630 (77.8)	640 (80.0)	0.89 (0.62, 1.29)	0.55	610 (75.3)	644 (80.5)	0.74 (0.49, 1.12)	0.15
Sleep duration (SD)	476 (58.8)	440 (55.0)	479 (59.1)	447 (55.9)	1.12 (0.91, 1.39)	0.28	492 (60.7)	447 (55.9)	1.20 (0.91, 1.58)	0.19
Screen time (ST)	595 (73.5)	599 (74.9)	594 (73.3)	541 (67.6)	1.36 (1.02, 1.82)	0.036	592 (73.1)	548 (68.5)	1.26 (0.93, 1.71)	0.13
Movement behaviour practice for last 2 weeks										
Physical activity time (PAT)	192 (23.7)	217 (27.1)	331 (40.9)	263 (32.9)	1.51 (1.17, 1.96)	0.0017	359 (44.3)	250 (31.3)	1.94 (1.42, 2.64)	<0.0001
Outdoor time (OT)	482 (59.5)	491 (61.4)	553 (68.3)	497 (62.1)	1.41 (1.07, 1.86)	0.014	549 (67.8)	442 (55.3)	1.82 (1.38, 2.39)	<0.0001
Physical restraint (PR)	588 (72.6)	612 (76.5)	612 (75.6)	626 (78.3)	0.92 (0.64, 1.31)	0.63	590 (72.8)	628 (78.5)	0.78 (0.54, 1.13)	0.19
Sleep duration (SD)	456 (56.3)	433 (54.1)	466 (57.5)	454 (56.8)	1.02 (0.81, 1.29)	0.86	468 (57.8)	430 (53.8)	1.17 (0.89, 1.54)	0.25
Screen time (ST)	580 (71.6)	582 (72.8)	584 (72.1)	530 (66.3)	1.39 (1.05, 1.84)	0.024	577 (71.2)	533 (66.6)	1.27 (0.93, 1.74)	0.14
Movement behaviour knowledge (caregivers know recommendations)										
Physical activity time (PAT)	141 (17.6)	155 (19.1)	319 (39.4)	201 (25.1)	1.97 (1.47, 2.64)	<0.0001	378 (46.7)	221 (27.6)	2.35 (1.75, 3.16)	<0.0001
Outdoor time (OT)	475 (58.6)	486 (60.8)	562 (69.4)	486 (60.8)	1.56 (1.14, 2.13)	0.0063	588 (72.6)	431 (53.9)	2.38 (1.76, 3.22)	<0.0001
Physical restraint (PR)	598 (73.8)	577 (72.1)	613 (75.7)	616 (77.0)	0.93 (0.63, 1.24)	0.60	607 (74.9)	604 (74.9)	0.95 (0.66, 1.36)	0.78
Sleep duration (SD)	435 (53.7)	384 (48.0)	436 (53.8)	421 (52.6)	1.02 (0.80, 1.29)	0.90	445 (54.9)	405 (50.6)	1.17 (0.88, 1.55)	0.28
Screen time (ST)	768 (94.8)	761 (95.1)	737 (91.0)	716 (89.5)	1.23 (0.75, 2.04)	0.41	737 (91.0)	710 (88.8)	1.30 (0.84, 2.01)	0.24

^aGeneralized linear mixed models allowing for the cluster effect were used to analyze outcomes, with adjustment for baseline values of the outcome measures, children's age, sex, and primary caregivers.

Table 3: Intervention effects on movement behaviour outcomes (movement behaviour group as intervention; feeding group as control).

increase in feeding practice indicators (MMF, MDD, MAD and CIRIFF) and 5–16 percent points increase of some movement behaviour practice indicators (PAT and OT), and some indicators were not improved (screen time and physical restraint). Exposure to more than one IYCF intervention delivering through different platforms has been proven to be more successful in

improving IYCF outcomes compared with a single form of intervention delivered at a single setting.⁴ Interventions delivered through multiple settings may have an increased intensity that can be translated into behavioural changes due to repeated contacts and adequate coverage of interventions.³⁶ Caregivers' information sources in our study were 60% from health

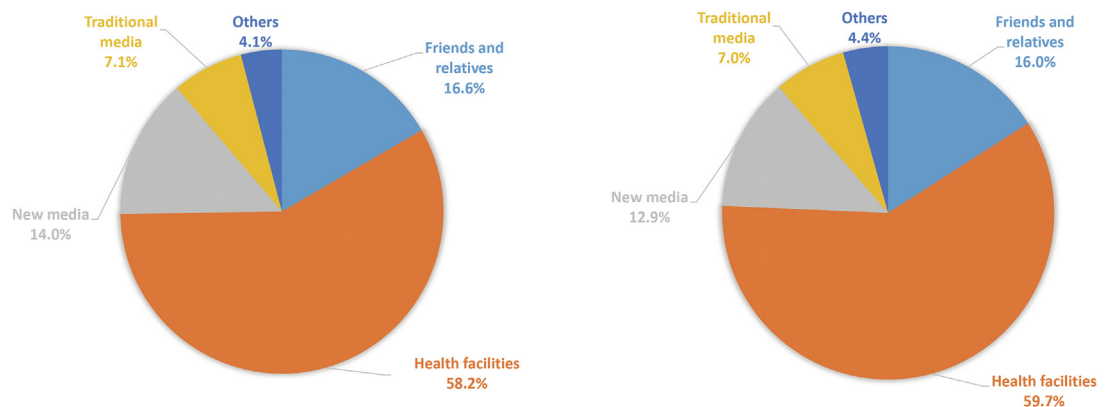


Fig. 2: Information source of complementary feeding (left) and movement behaviour (right).^a ^a The information source questions are the multiple-choice questions which mean all sources of information mentioned by interviewees are recorded as 'yes'. To calculate the proportions, all 'yes' answers in different categories are summed up as denominators, and all 'yes' answers in each category are summed up as numerators.

facilities and 10% from new media. Therefore, health education from health facilities still plays a vital role. In this study, village doctors only recruited participants and sent questionnaires, and were not involved in the intervention. Future interventions could involve village doctors to check children's reports and provide further explanation and advice for the report.

To our knowledge, this study is the first cluster randomized controlled trials to show effective IYCF feeding practice and movement behaviours improvement using a WeChat-based self-assessment with a tailored feedback. In addition, it is universally accepted that the rate of participants lost to follow-up is associated with the potential risk of bias in randomized controlled trials (RCTs).³⁷ Therefore, it is very important to ensure follow up enough participants.³⁸ In this cluster randomized controlled trial, we followed up all the participant at the two follow-ups, which was in line with high response rate (98.2%) for WeChat based data collection of IYCF data in our previous study.²⁸ Several reasons could explain no loss to follow-up in our study. First, we excluded children with caregivers who refused to provide their WeChat number before randomized. Second, it took only about 10 min to fill in the questionnaire. Third, we asked village doctors to inform caregivers of the feedback report before filling in the questionnaire so that they knew that this was not only to collect data but also to provide them with advice. Finally, for those who did not filling in the questionnaires, we asked the village doctors to remind caregivers.

Our study also had several limitations. First, we did not have a pure control group, as we used the two-intervention group mutually as control groups. However, the intervention messages (feeding and movement behaviour information in the two groups, respectively) were completely different, therefore, pure data collection without feedback report would not influence caregivers' practice in the control group. Second caregivers were not blinded to the interventions, and they might understand what information was going to be asked in their outcomes assessment, which would lead to inflated treatment effect estimates. Whereas, we adjusted baseline values of the outcome measures when analyzing the treatment effect to mitigate the impact of response bias. Third, this study took place only in one rural counties in China, so the generalization of the results requires caution.

In conclusion, our findings strongly support that the WeChat-based self-assessment with tailored feedback intervention effectively improved complementary feeding practices and movement behaviours of children aged 6–20 months in rural China. Further studies are needed to assess the generalizability of health information delivered through WeChat as well as other social media in other areas in China and other low- and

	Feeding group (N = 800) n (%)	Movement behaviour group (N = 810) n (%)	Total (N = 1610) n (%)
Number of times questionnaire was filled out			
1	40 (5.0)	35 (4.3)	75 (4.7)
2	80 (10.0)	96 (11.9)	176 (10.9)
3	539 (67.4)	524 (64.7)	1063 (66.0)
≥4	141 (17.6)	155 (19.1)	296 (18.4)
Usefulness of self-assessment tool			
Very useful	412 (51.5)	403 (49.8)	815 (50.6)
Useful	324 (40.5)	365 (45.1)	689 (42.8)
Useless	64 (8.0)	42 (5.1)	106 (6.6)
Ever read the feedback report	731 (91.4)	725 (89.5)	1456 (90.4)
Usefulness of feedback report			
Very useful	394 (53.9)	390 (53.8)	784 (53.8)
Useful	304 (41.6)	322 (44.4)	626 (43.0)
Useless	33 (4.5)	13 (1.8)	46 (3.2)
Ever watched the health education video for the feedback report	640 (80.0)	630 (77.8)	1270 (78.9)
Usefulness of the health education video for the feedback report			
Very useful	373 (58.3)	351 (55.7)	724 (57.0)
Useful	254 (39.7)	273 (43.3)	527 (41.5)
Useless	13 (2.0)	6 (1.0)	19 (1.5)

Table 4: Evaluation of self-assessment tool by caregivers.

middle-income countries (LMICs), and assess the effects of the multi-channel interventions on behavioural change and nutritional status of children.

Contributors

YZ conceptualized, designed, and supervised the study; QW and XTW collected, access, and verified the data, conducted data analysis, and wrote the initial manuscript; YZ, QW, MV, JZ, and XTW interpreted the results and made substantial revision of the manuscript. All authors read and approved the final version for submission.

Data sharing statement

Anonymized data will be made available upon approved request from the corresponding author. The study protocol, statistical analysis plan, and informed consent form will also be made available on request.

Declaration of interests

The authors declare no relevant interest of conflict.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.lanwpc.2023.100796>.

References

- 1 Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet*. 2013;382:427–451.

- 2 Mizuno Katsumi. The first 1000 days of life. *Pediatr Int*. 2019;61(1):3.
- 3 Arts J, Gubbels JS, Verhoeff AP, Chinapaw MJM, Lettink A, Altenburg TM. A systematic review of proxy-report questionnaires assessing physical activity, sedentary behavior and/or sleep in young children (aged 0-5 years). *Int J Behav Nutr Phys Act*. 2022;19(1):18. <https://doi.org/10.1186/s12966-022-01251-x>. PMID: 35164783; PMCID: PMC8845346.
- 4 Ahmed KY, Agho KE, Page A, Arora A, Ogbo FA, on behalf of the Global Maternal and Child Health Research Collaboration (GloM-ACH). Interventions to improve infant and young child feeding practices in Ethiopia: a systematic review. *BMJ Open*. 2021;11(8):e048700. <https://doi.org/10.1136/bmjopen-2021-048700>.
- 5 D'Auria E, Borsani B, Penderza E, et al. Complementary feeding: pitfalls for health outcomes. *Int J Environ Res Public Health*. 2022;17(21):7931. <https://doi.org/10.3390/ijerph17217931>. PMID: 33137971; PMCID: PMC7662522.
- 6 WHO, UNICEF. *Global strategy for infant and young child feeding*. Geneva: WHO; 2003.
- 7 WHO, UNICEF, USAID, AED, IFPRI. *Indicators for assessing infant and young child feeding practices part I: definition*. Geneva: WHO; 2010.
- 8 Ministry of Health, People Republic of China. *Ministry of Health Implementation guidelines on national basic public health service program* [in Chinese]; 2009. Available: <http://www.nhc.gov.cn/cms-search/xxgk/getManuscriptXxgk.htm?id=43183>. Accessed July 18, 2022.
- 9 Liu J, Huo J, Sun J, Huang J, Gong W, Wang O. Prevalence of complementary feeding indicators and associated factors among 6- to 23-month breastfed infants and young children in poor rural areas of China. *Front Public Health*. 2021;9:691894. <https://doi.org/10.3389/fpubh.2021.691894>. PMID: 34660508; PMCID: PMC8517442.
- 10 Xu X, Yu D, Zhao L, et al. Complementary feeding time among 0-5 years old children in 2013 in China. *Wei Sheng Yan Jiu*. 2018;47(5):695-699.
- 11 Sirkka O, Abrahamse-Berkeveld M, van der Beek EM. Complementary feeding practices among young children in China, India, and Indonesia: a narrative review. *Curr Dev Nutr*. 2022;6(6):nzac092. <https://doi.org/10.1093/cdn/nzac092>. PMID: 35769448; PMCID: PMC9233619.
- 12 Wu Q, Huang Y, van Velthoven MH, Wang W, Zhang Y. Trends in complementary feeding practices and caregivers' feeding knowledge among children aged 6-23 months: repeated cross-sectional surveys in rural Qinghai China 2012-18. *J Glob Health*. 2021;11:08003.
- 13 Zhang Z, Predy M, Hesketh KD, Pritchard L, Carson V. Demographic correlates of movement behaviors in infants: a longitudinal study. *J Phys Act Health*. 2022;19(3):177-185. <https://doi.org/10.1123/jpah.2021-0570>. PMID: 35135898.
- 14 Santos R, Zhang Z, Pereira JR, Sousa-Sá E, Cliff DP, Okely AD. Compliance with the Australian 24-hour movement guidelines for the early years: associations with weight status. *BMC Public Health*. 2017;17(Suppl 5):867.
- 15 Kracht CL, Webster EK, Staiano AE. Relationship between the 24-hour movement guidelines and fundamental motor skills in preschoolers. *J Sci Med Sport*. 2020;23(12):1185-1190.
- 16 World Health Organization. *Guideline for 24-h physical activity, sedentary behaviour and sleep for children under 5 years of age*. Geneva: WHO; 2019. <https://www.who.int/publications/i/item/9789241550536>. Accessed June 20, 2022.
- 17 Composing and Editorial Board of Physical Activity Guidelines for Chinese. *Physical activity guidelines for Chinese (2021)*. *Chin J Epidemiol*. 2022;43(1):5-6.
- 18 Choe EK, Sakamoto Y, Fatmi Y, et al. Persuasive data videos: investigating persuasive self-tracking feedback with augmented data videos. *AMIA Annu Symp Proc*. 2019;2019:295-304. PMID: 32308822.
- 19 Kroeze W, Werkman A, Brug J. A systematic review of randomized trials on the effectiveness of computer-tailored education on physical activity and dietary behaviors. *Ann Behav Med*. 2006;31(3):205-223. https://doi.org/10.1207/s15324796abm3103_2. PMID: 16700634.
- 20 de Vries H, Kremers SP, Smeets T, Brug J, Eijmael K. The effectiveness of tailored feedback and action plans in an intervention addressing multiple health behaviors. *Am J Health Promot*. 2008;22(6):417-425. <https://doi.org/10.4278/ajhp.22.6.417>. PMID: 18677882.
- 21 Kitagawa T, Higuchi Y, Todo E, Ueda T, Ando S, Murakami T. Tailored feedback reduced prolonged sitting time and improved the health of housewives: a single-blind randomized controlled pilot study. *Women Health*. 2020;60(2):212-223. <https://doi.org/10.1080/03630242.2019.1616043>. PMID: 31113310.
- 22 Ogunsanya ME, Sifat M, Bamidele OO, et al. Mobile health (mHealth) interventions in prostate cancer survivorship: a scoping review. *J Cancer Surviv*. 2023. <https://doi.org/10.1007/s11764-022-01328-3>. Epub ahead of print. PMID: 36627464.
- 23 Salas-Groves E, Galyean S, Alcorn M, Childress A. Behavior change effectiveness using nutrition apps in people with chronic diseases: scoping review. *JMIR Mhealth Uhealth*. 2023;11:e41235. <https://doi.org/10.2196/41235>. PMID: 36637888.
- 24 Wu Q, Huang Y, Liao Z, van Velthoven MH, Wang W, Zhang Y. Effectiveness of WeChat for improving exclusive breastfeeding in Huzhou county China: randomized controlled trial. *J Med Internet Res*. 2020;22(12):e23273. <https://doi.org/10.2196/23273>. PMID: 33270026; PMCID: PMC7746496.
- 25 Dong Y, Wang P, Dai Z, et al. Increased self-care activities and glycemic control rate in relation to health education via WeChat among diabetes patients: a randomized clinical trial. *Medicine*. 2018;97(50):e13632.
- 26 Cao Y, Lin S, Zhu D, et al. WeChat public account use improves clinical control of cough-variant asthma: a randomized controlled trial. *Med Sci Monit*. 2018;24:1524-1532.
- 27 Liu A, Zhang J, Wu Q, Zhang Y, van Velthoven M. Comparison of the agreement between WeChat-based self-administered and interviewer-administered data on infant and young child feeding in China: a test-retest study. *J Glob Health*. 2022;12:11004. <https://doi.org/10.7189/jogh.12.11004>. PMID: 35726544; PMCID: PMC9210156.
- 28 Zhang J, Wu Q, Wang X, Zhang Y, Helena van Velthoven M. High response rate and low cost of WeChat-based data collection of infant and young child feeding data in rural Qinghai Province, China. *J Glob Health*. 2022;12:11011. <https://doi.org/10.7189/jogh.12.11011>. PMID: 36269216; PMCID: PMC9586143.
- 29 Fralick M, Haj R, Hirpara D, et al. Can a smartphone app improve medical trainees' knowledge of antibiotics? *Int J Med Educ*. 2017;8:416-420.
- 30 Plotnikoff RC, Wilczynska M, Cohen KE, Smith JJ, Lubans DR. Integrating smartphone technology, social support and the outdoor physical environment to improve fitness among adults at risk of, or diagnosed with, type 2 diabetes: findings from the 'eCoFit' randomized controlled trial. *Prev Med*. 2017;105:404-411.
- 31 Haskins BL, Lesperance D, Gibbons P, Boudreaux ED. A systematic review of smartphone applications for smoking cessation. *Transl Behav Med*. 2017;7(2):292-299.
- 32 Kreps GL. The relevance of health literacy to mHealth. *Stud Health Technol Inform*. 2017;240:347-355. PMID: 28972527.
- 33 Global Data. Literacy rate in China (2018-2021, %). <https://www.globaldata.com/data-insights/macroeconomic/literacy-rate-in-china/>. Accessed December 7, 2022.
- 34 The Lancet Diabetes Endocrinology. Obesity in China: time to act. *Lancet Diabetes Endocrinol*. 2021;9(7):407. [https://doi.org/10.1016/S2213-8587\(21\)00150-9](https://doi.org/10.1016/S2213-8587(21)00150-9). PMID: 34097870.
- 35 Hart CN, Jelalian E, Raynor HA. Behavioral and social routines and biological rhythms in prevention and treatment of pediatric obesity. *Am Psychol*. 2020;75(2):152-162.
- 36 Sanghvi T, Seidel R, Baker J. Using behavior change approaches to improve complementary feeding practices. *Matern Child Nutr*. 2017;13:e12406.
- 37 Sackett DL. Evidence-based medicine. *Semin Perinatol*. 1997; 21(1):3-5. [https://doi.org/10.1016/s0146-0005\(97\)80013-4](https://doi.org/10.1016/s0146-0005(97)80013-4). PMID: 9190027.
- 38 Gul RB, Ali PA. Clinical trials: the challenge of recruitment and retention of participants. *J Clin Nurs*. 2010;19:227-233. <https://doi.org/10.1111/j.1365-2702.2009.03041.x>. Medline:20500260.