A pilot mHealth text-messaging program targeting parents during the first 2000 days: a non-randomized, repeat cross-sectional analysis to pragmatically evaluate feasibility, engagement, acceptability and potential effectiveness within the Hunter New England region of New South Wales, Australia.

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Table of Contents

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Abstract

Background: The first 2000 days of a child's life represents a critical window for growth and development, profoundly influencing long-term physical health, cognitive outcomes, and the risk of future chronic disease. Healthy Beginnings for Hunter New England Kids (HB4HNEKids) is a text-messaging program delivered alongside routine Child and Family Health Nursing (CFHN) care which provides families with easy to access, evidence-based, age and stage related preventive health information across the first 2000 days.

Objective: This pilot study explores the feasibility, engagement and acceptability of the HB4HNEKids program when embedded into routine CFHN service delivery. It also explores the potential effectiveness of the program at 6- and/or 12-months post-partum on outcomes including: breastfeeding, child diet, child movement, and parental mental well-being.

Methods: During the pilot phase (October 2021-July 2024), project record data was used to assess the number of families enrolled and number of text-messages sent (feasibility), and the number of families that opt-out (engagement). Repeat cross-sectional online or telephone surveys were conducted at 5-7 months post-partum (T1, May-December 2022) and again at 12-14 months post-partum (T2, August 2023-July 2024), with birthing parents who had received HB4HNEKids, and a concurrent non-randomized comparison group located within the Hunter New England region of New South Wales, Australia that did not receive the program. Surveys assessed parental self-reported engagement with the messages, and program acceptability, as well as health behaviors including breastfeeding status, child diet, child movement and parental mental wellbeing. Unadjusted and adjusted mixed linear regression analyses were conducted to calculate mean differences (MD) and odds ratios (OR).

Results: During the pilot phase, HB4HNEKids was delivered to 6243 families (73.4% of families contacted by CFHN). A total

of 383 birthing parents completed the survey at 6 months (26% receiving HB4HNEKids), and 283 completed the survey at 12 months (37% receiving HB4HNEKids). Of the survey participants who received HB4HNEKids (n=200), between 76-83% reported that they always or very often read the text-messages, spending on average 5-7 minutes engaged with the content. At both survey timepoints, over 90% of participants receiving HB4HNEKids agreed the program was acceptable. Child daily intake of vegetables was significantly higher in the HB4HNEKids group (adjusted MD: 0.23 (95% CI: 0.07 to 0.40), P=.006) compared with the comparison group at 12 months. Parents receiving HB4HNEKids also reported significantly better mental wellbeing scores than those in the comparison group (P=.005). While HB4HNEkids participants reported breastfeeding rates 5 percentage points greater than comparison participants at 6 and 12-months, this result was not statistically significant. There were no statistically significant differences between HB4HNEKids, and comparison participant responses related to child movement behaviors.

Conclusions: The HB4HNEKids text-messaging program is feasible to deliver at scale alongside routine CFHN care and is highly acceptable and engaging to parents. This pragmatic evaluation of the pilot, embedding into usual care, indicates potential effectiveness of the program for improving child vegetable intakes and parental mental wellbeing. Further evaluation of this program within larger samples using robust methodology is needed to determine the effectiveness of this innovative mHealth program across the first 2000 days.

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Keywords:
Digital health; mHealth; text-message; first 2000 days; child health; feasibility; acceptability; cross sectional.

Introduction

The first 2000 days of life, represents a critical period between conception through to 5 years, that significantly impacts on child physical, emotional, social and cognitive development, laying the foundations for a child's lifelong trajectories [1]. Breastfeeding practices, introduction to solid foods, development of movement behaviors and optimal parental mental wellbeing can significantly influence child health and developmental outcomes [2-4]. The mental wellbeing of parents can influence the quality of care given to infants and is associated with a variety of child health and developmental outcomes [5-7]. Whilst longer breastfeeding duration, child consumption of fruits and vegetables and increased physical activity are associated with enhanced cognitive development and reduced lifelong risk of chronic disease [2-4, 8], current data suggests these outcomes are below national and international targets [9-11].

In alignment with key international, national and state level health policy, Child and Family Health Nursing (CFHN) services in New South Wales (NSW), Australia, provide care and support to families following the birth of infants, with the goal of enhancing child and family health, development and wellbeing during the first 2000 days [12, 13]. The services offered by CFHN are primarily delivered face-to-face and align to scheduled health and developmental checks, providing lactation education, emotional support, vaccinations, preventive health advice, screening and secondary referral pathways. However, due to various health service barriers (e.g. staff capacity, geographic location), care focuses on supporting families during the first few months of the child's life, with ongoing targeted services prioritized for those identified with additional needs. Furthermore, accessing face-to-face preventative health services, can be challenging for parents, given caregiving responsibilities and work commitments [14, 15]. Therefore, population wide engagement with CFHN care significantly declines over the first 2000-day period, resulting in fragmented service utilization [16]. This highlights the need for inclusive and accessible preventive health services to ensure all families receive timely, trusted and evidence-based support throughout the course of the first 2000 days.

Mobile Health (mHealth) interventions represent a promising strategy to overcome some of the barriers to the traditional face-to-face support offered during the first 2000 days. Given that access to mobile phones and smartphones is relatively ubiquitous [17, 18], mHealth interventions, including targeted text messages delivered directly to parent/carer mobile phones, could improve the delivery of preventative care and health promotion during the first 2000 days [19]. This concept is supported by formative research conducted within the Hunter New England (HNE) region of NSW, Australia that found parents are highly accepting of receiving CFHN support via a variety of technology modalities (including websites, email and text-messaging) on a variety of child and family health promoting topics (including healthy eating, introduction to solids, breastfeeding, sleep and healthy growth)[20]. Systematic reviews also demonstrate mHealth is effective in increasing multiple health behaviors including frequency of maternal contact with antenatal care, child immunization rates, and improving maternal and child health outcomes such as anxiety and depression, obesity prevention

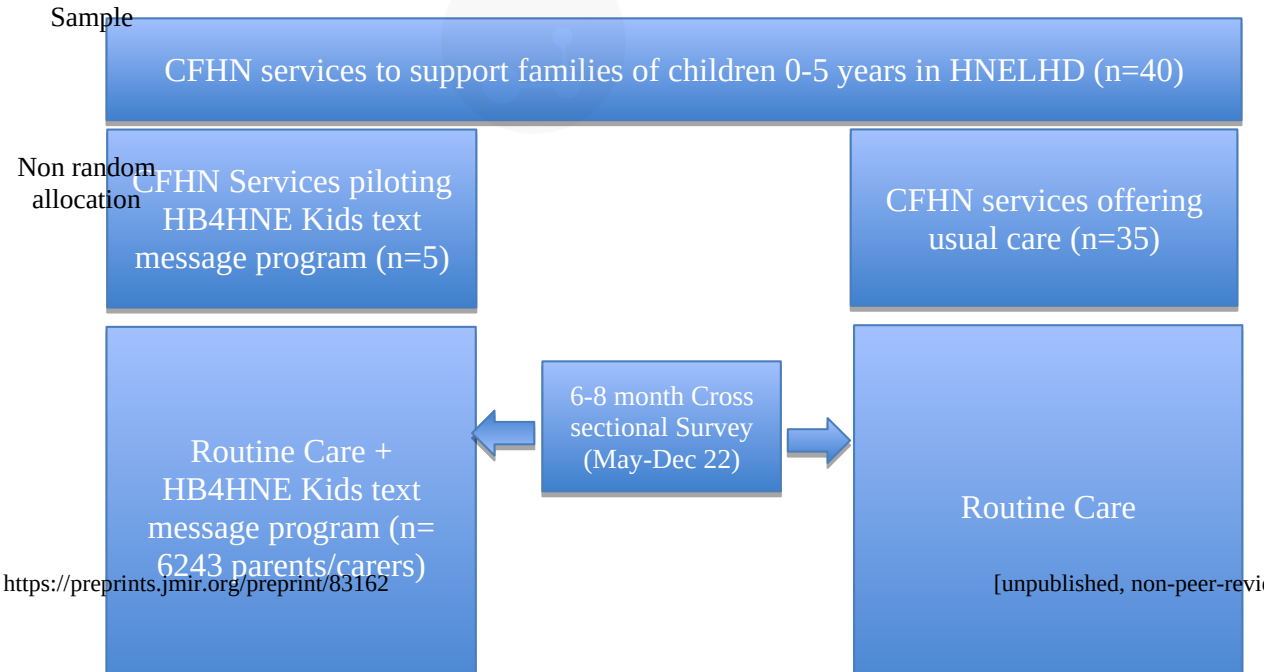
and exclusive breastfeeding rates [21-26]. Additionally, a randomized controlled trial conducted under robust research conditions demonstrates the efficacy of parent targeted text-messaging interventions for improving infant feeding practices (i.e. bottle use at bedtime) and reducing screen time [27]. This highlights the potential for text message-based interventions during the first 2000 days.

Despite the potential of mHealth interventions, few effective interventions have been embedded into health service delivery and implemented in real world settings during the first 2000 days [28-30]. For mHealth interventions to effectively improve population health, they must be integrated into the settings, services, or health systems that reach the intended target population [30]. Given the limited translation of effective mHealth programs into usual health service delivery and building on the robust research evidence [19], there is a need to evaluate the feasibility, engagement, acceptability and potential effectiveness of research innovations when embedded into routine care. The aim of this study was to pragmatically evaluate the feasibility, engagement and acceptability of the pilot HB4HNEKids program when embedded into routine CFHN service delivery. This pilot also explores the potential effectiveness of HB4HNEKids for improving child and parental health and wellbeing outcomes at 6- and/or 12- months post-partum, including: (1) breastfeeding; (2) child nutrition; (3) child movement and (4) parental mental well-being.

Methods

Study Design

The feasibility, engagement, acceptability and potential effectiveness of a text-messaging model of care delivered to families during the first 2000 days was evaluated as part of an observational study with a non-randomized control arm. This study involved two cross-sectional surveys conducted with a convenience sample of birthing parents located in the Hunter New England Local Health District (HNELHD) of NSW, Australia. As the text-messaging program (HB4HNEKids) was initially launched in October 2021 to parents attending five pilot CFHN services across three diverse local government areas (Armidale, Cessnock and Newcastle/Lake Macquarie), the cross-sectional surveys include a sub-sample of participants that had received HB4HNEKids, and a concurrent non-randomized comparison group of parents who did not receive HB4HNEKids.
The first cross-sectional survey was undertaken between May and December 2022 and included birthing parents 5-7 months post-partum. The second cross-sectional survey was conducted between August 2023 and July 2024 and included birthing parents 12-14 months post-partum. (See Figure 1)



Intervention

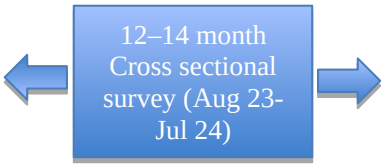


Figure 1. Flow of participants through the study

Ethics approval

Ethics approval for all maternal data was obtained from the Hunter New England Human Research Ethics Committee (16/11/16/4.07), Aboriginal Health and Medical Research Council (1236/16) and the University of Newcastle Human Research Ethics Committee (H-2017-0032). This research was conducted in compliance with informed consent guidelines and adhered to national law and regulations regarding the protection of personal information, privacy and human rights.

Data collection procedures

Both the 6-month and 12-month surveys were developed using the Research Electronic Data capture (REDCap, version 14.1.2 - © 2025 Vanderbilt University) tool, hosted by HNELHD which is a secure research electronic database commonly used in health service research [31, 32]. Participants either completed the survey online or computer assisted telephone interview (CATI). Survey consent and responses were also stored in REDCap, providing a central survey database.

Eligibility for participation in the surveys

To evaluate the effectiveness of the pilot HB4HNEKids text-messaging program, a cross-section of birthing parents who had accessed HNELHD maternity services were invited to participate in a survey at two time points. For the first survey, eligibility criteria for birthing parents were: 26-37 weeks (i.e. approximately 6 months) post-partum; aged 18 years or older; had received antenatal care from any public antenatal service in HNE (providing antenatal care to approximately 70% of women across the district); had not had an unfortunate pregnancy related outcome (i.e. still birth); able to communicate in English; had previously provided consent to participate in a survey of antenatal care; and agreed to be contacted for future surveys. Eligibility for the second survey was the same as the first survey, except birthing parents needed to be approximately 12-months post-partum and have reached >34 weeks gestation to be eligible to complete the survey.

Recruitment of participants to participate in the survey

As per ethics approval, electronic medical records and previous antenatal survey data were used to identify the sample. Using this method, birthing parents that met eligibility criteria for survey participation were mailed printed information statements, providing an outline of the survey and a toll-free number to withdraw or decline participation.

Recruitment of non-Aboriginal participants to the survey

Participants were sent information statements if their child met the eligibility criteria for participation. One week after information statements were mailed, birthing parents were contacted by telephone and invited to participate in the survey via a CATI. Birthing parents received up to 10 phone call attempts over a two-week period to invite survey participation. As per ethics approval, verbal consent to participate in the surveys was sought from the birthing parent at the time of the interview. Birthing parents who declined to participate during the CATI were offered the opportunity to complete the survey online and were sent an individual survey link to their mobile number or

email address. Prior to accessing the online survey, participants were reminded in the survey's display screen that participation was voluntary and that it was possible to decline the survey at any point. Participant consent into the study and survey completion status (both via the CATI and online) were saved into a central survey database, in REDCap, held by the research team.

Recruitment of Aboriginal participants to the survey

Following advice provided from local cultural consultation, birthing parents identifying as Aboriginal and/or Torres Strait Islander were sent a text message three days after the mail out of the information statement. The text message offered one of three options: (1) to complete the survey via CATI; (2) to complete the survey online; or (3) decline participation. Participants could respond to the text message to indicate their preferred method of contact. Those who opted to complete the survey online were sent an individual survey link to their mobile number which was active for two weeks. Those who opted to complete the survey via telephone or did not reply to the text message within five days received a phone call from a female interviewer and were invited to participate in the study.

The text-messaging program- Healthy Beginnings for Hunter New England Kids (HB4HNEKids)

Healthy Beginnings for Hunter New England Kids (HB4HNEKids) is a mHealth text messaging program providing parents/carers with age-and-stage relevant preventative health information. The program is an adapted version of an RCT that demonstrated impact on reducing screentime and bottle use at bedtime at 12 months [33]. The HB4HNEKids program was adapted to strengthen a range of behavioral outcomes, supporting parents and children to develop preventive health behaviors during the first 2000 days. Implementation focused on overcoming health system and parent barriers to accessing health services and was therefore designed to be delivered alongside routine CFHN care. HB4HNEKids aims to offer timely, age-and-stage-appropriate health promotion information directly to parents' and carers' mobile phones including preventive health information such as breastfeeding, infant feeding, movement behaviors and parental wellbeing. The program also offers reminders for scheduled child health checks and immunizations, early developmental screening and information on available support services.

Program adaptation process

HB4HNEKids was adapted from a prior RCT [33] to strengthen the effectiveness of text-message support offered across the first 2000 days and enhance alignment to usual CFHN care delivery. The HB4HNEKids program focuses on six key health behaviors, aligned with specific age-and-stage developmental milestones and key policy frameworks targeting the first 2000 days [13, 34, 35]. The process of adaptation involved: 1) Identifying priority health behaviors from policy frameworks, strategic plans and expert consultation; 2) Review of the literature to identify determinants of priority health behaviors; 3) The use of behavioral theory (e.g. Behavior Change Wheel (BCW) [36] and Theoretical Domains Framework (TDF) [37]) to develop text messages embedding behavior change techniques to address the identified determinants and 4) Co-design of text-messages collaboratively with HNELHD health practitioners including CFHN, allied health professionals, public health practitioners, Aboriginal health workers and representatives from multicultural health to ensure wording and intent aligned with usual care (See Figure 2).

All eligible families were offered HB4HNEKids either prior to or during the face-to-face routine 1-4-week health check provided by CFHN services, as a digital program offered alongside usual care. The HB4HNEKids text messages were short (often less than 160 characters), included clickable links to evidenced-based 'online' videos, fact sheets, websites and relevant support services. Parents

receiving the HB4HNEKids program were sent up to 44 text messages in the first 6 months and a further 28 between 6-12 months, to their nominated mobile number. Messages were sent seven days a week, generally between the hours of 9:00AM to 12:00PM. While most messages were designed to be a one-way text message, the exception was the two-way text sent to participants to confirm infant feeding status (on days 21, 97 and 150). Responses to feeding status were received in the messaging platform. Feeding status responses were stored in REDCap and monitored by a member of the research team each weekday. By collecting feeding status, the program content was tailored to better meet the individual needs of the participant (e.g. families who were exclusively formula feeding did not receive content related to breastfeeding). Participants were sent a link on day 1, 51 and 296, which allowed participants to opt-out and automatically unsubscribe from the program upon clicking. The opt out links remained valid/open allowing the participant to opt out of the program at any time.

Eligibility for receipt of HB4HNEKids program

All parents in HNELHD who had recently given birth are referred to CFHN services to receive ongoing care for their child until age five. Parents due to receive a 1-4-week health check from one of the five participating CFHN services located in the HNELHD between October 2021 and July 2024 were eligible for the HB4HNEKids text message program alongside their usual CFHN care. Parents needed to have access to a mobile phone to be eligible to receive the program.

Recruitment of women to the HB4HNEKids program

As per the existing health service procedures, CFHN services received a referral from public and private maternity services in the HNELHD following the birth of a baby and discharge of the parent from hospital [38]. CFHN service staff then contacted birthing parents in their local catchment area to offer a 1-4-week health check, which typically occurs within 3 business days of receipt of the CFHN referral. Staff from pilot CFHN services were encouraged to offer the HB4HNEKids program to all birthing parents within their catchment area. At the initial booking in contact, CFHN staff confirmed feeding status (breastfeeding, mixed feeding, formula feeding), child name, mobile number and ‘clinician offer of service’ (yes, client refused, unable to contact after multiple attempts) and recorded this in a REDCap[32]. If CFHN service staff were unable to determine infant feeding status during the initial call (i.e. due to language barriers), they would locate infant feeding status via the discharge summary provided by maternity services and enter this into REDCap.

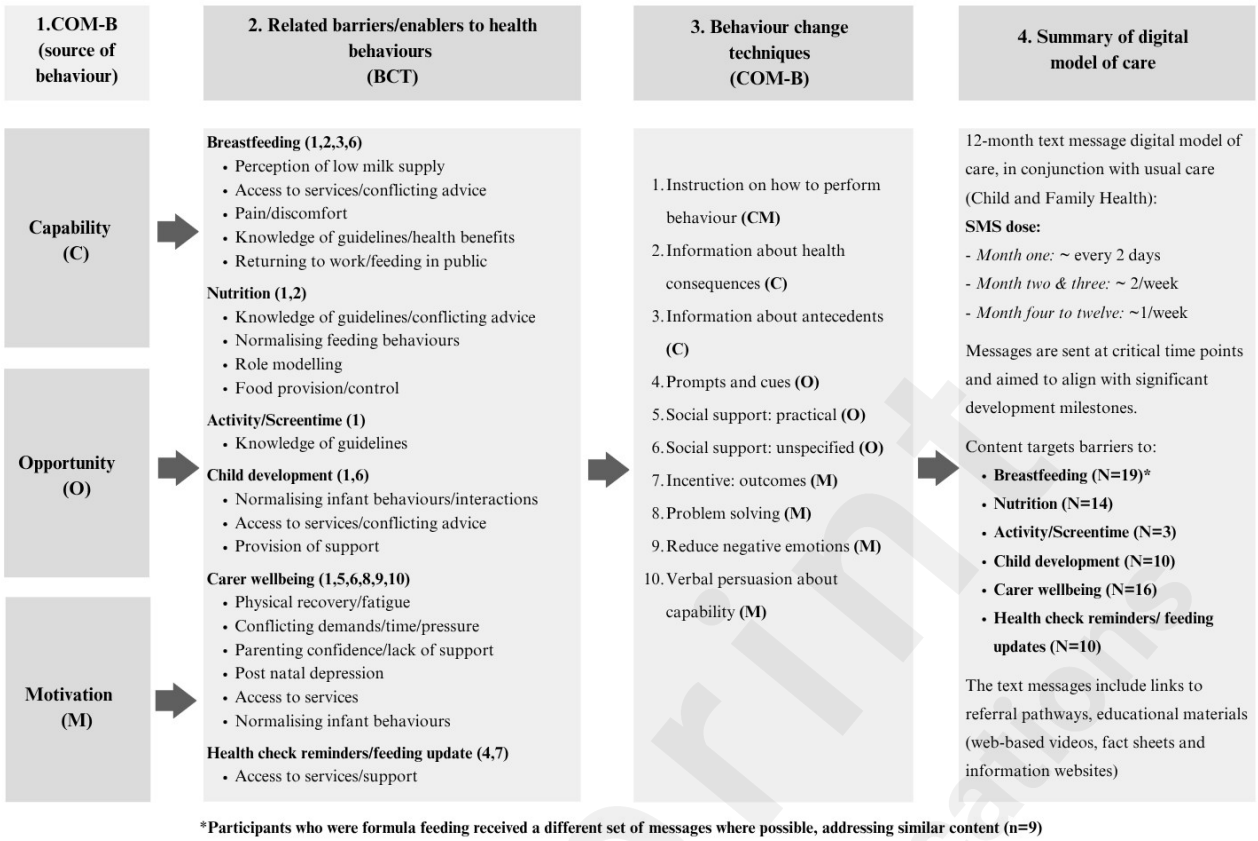


Figure 2. HB4HNEKids logic model

Outcome Measures

Feasibility of delivering HB4HNEKids via routine CFH care

During the relevant pilot timeframe (October 2021-July 2024), project record data (securely stored in REDCap) was used to assess feasibility of the program as follows:

- Number of families enrolled in the HB4HNEKids program,
- Proportion of families enrolled in the HB4HNEKids program relative to the number of families contacted by CFHN services for the 1-4-week appointment,
- Number of families who opted out of the HB4HNEKids program,
- Number of messages sent as part of the HB4HNEKids program.

Engagement with HB4HNEKids content

Within the 6 month and 12-month surveys, parents who had received HB4HNEKids were asked to report their engagement with the program text-message content. These items assessed how often a participant read the text messages and how often they clicked the website links within the text messages, with response options including Always, Very-often, Sometimes, Rarely and Never. Participants were also asked to report average time spent (in minutes) engaged in the text message content and links.

Acceptability of HB4HNEKids

To assess parent acceptability of the HB4HNEKids text-messaging program, measures of program acceptability were adapted from the psychometrically validated Acceptability of Intervention Measure (AIM), by Weiner et al [39]. All survey items were assessed on a five-point Likert scale (strongly disagree=1, disagree=2, neither agree nor disagree=3, agree=4, strongly agree=5).

Participants were coded as ‘agreeing’ to statements, if they responded ‘strongly agree’ or ’agree’ to any of the statements. Responses to AIM items were grouped according to a) acceptability of the overall program; b) acceptability of text-message timing; c) acceptability of text-message content; and d) acceptability of linked resources.

Potential effectiveness

Breastfeeding status, introduction to solids and breastfeeding self-efficacy at 6- and 12-months

Infant feeding survey items were adapted from local, state and national infant feeding surveys [40]. As per the Australian National Infant Feeding Survey (ANIFS), ‘current’ breastfeeding status was reported if a parent reported ‘yes’ to their *‘baby had received breastmilk since this time yesterday’*. Breastfeeding duration was assessed in accordance with Centre for Disease Control definitions of breastfeeding duration [41], as parents who had ceased breastfeeding were asked to report the age (in months) at which breastfeeding ceased. Participants were also asked to report age (in months) the infant was first introduced to soft, semi-solid or solid food, using survey items from the ANIFS [42].

The breastfeeding self-efficacy scale short form (BSES-SF) tool was used to assess maternal breastfeeding self-efficacy [43], which has consistently been demonstrated as a valid and reliable measure of breastfeeding self-efficacy globally [44]. The BSES-SF is a 14-item self-report instrument derived from the 33-item BSES tool measuring breastfeeding confidence. All items are preceded by the phrase ‘I think I can always” and rated on a 5-point Likert scale, ranging from 1 (not at all confident) to 5 (always confident). As such, total score ranges from 14 to 70, with a higher score indicating greater levels of breastfeeding self-efficacy. The items were assessed within both the 6-month and 12-month survey.

Child nutrition at 12-months

The Short Food Survey (SFS) developed by Hendrie et al. [45] is a 38-item tool that captures parent-reported information on children’s food group intakes and food choices, and has been shown to produce a reliable estimate of compliance with dietary guidelines [45]. Four survey items from the SFS were used to assess child intake of fruit and vegetables at 12-months. Fruit intake was assessed by asking parents “*How many serves of fruit does your child usually eat”*, including a prompt describing what a serve of fruit is (e.g. one serve is equal to 2 small pieces of fruit e.g. apricots, plums; 1 medium apple, banana or mandarin; or 1 cup of diced pieces e.g. diced peaches or diced fruit salad). To assess child intake of vegetables, responses to 3 survey items from the SFS were combined [45], including: “*How many servings of starchy vegetables (not including hot chips) does your child usually eat?”* (prompt: starchy vegetables include potatoes and sweet potatoes; one serve is equal to ½ a cooked potato); “*How many servings of salad vegetables does your child usually eat?”* (prompt: salad vegetables include vegetables such as tomato, capsicum, cucumber, lettuce and celery. A serve is equal to 1 cup of salad vegetables); “*How many servings of cooked vegetables does your child usually eat?*” (prompt: a serve is equal to ½ cup of cooked vegetables).

The Children’s Dietary Questionnaire (CDQ) [46], reliability assesses child intake patterns in either the previous week or 24 hours for which food intake are either recommended or discouraged (e.g. high fat/sugar products and sweetened beverages). We used survey items from the CDQ to measure the mean weekly frequency of discretionary food consumption, captured by combining responses related to the frequency of child intake of soft drinks (including cordial or sports drinks), takeaway foods (meals or snacks), chips (e.g. baked potato gems/ chips, hash browns, hot chops/French fries, wedges or fried potatoes), savory snacks (e.g. potato crisps, pretzels, plain/flavored crackers), sweet snacks (e.g. sweet biscuits, cakes, buns, muffins and doughnuts), savory pastries, snack bars (e.g. muesli bars or cereal bars), chocolate or lollies, and ice cream/ice-blocks. Items assessing child nutrition were only included within the 12-month survey.

Child movement behaviors at 12 months

The Movement Behavior Questionnaire-Baby (MBQ-B) is a validated 6-item tool designed to be administered to parents of children <18 months of age [47]. The MBQ-B assess frequency and duration of tummy time, time spent in active play/outdoor play, watching television and using mobile digital devices. Items from the MBQ-B were used to assess child movement, restrained time and screentime.

For active play, parents were asked "T*hinking about the past week, on a typical day, how much time in total did you do some active play with your child? Active play could be crawling on the floor with your child, rolling around the floor with your child, playing at the park, dancing with your child, chasing your child"*. The response options ranged from 0 minutes per day, to more than 2 hours per day. Given Australian 24-hour movement guidelines recommend that toddlers (1-2 years old) should achieve at least 3 hours of various physical activities each day, including energetic play, parents reporting "more than 2 hours per day" of active play were coded as having children meeting physical activity guidelines [48]. To explore restrained time, parents were asked to report "*On a typical day, how many times did you place your child in a baby carrier or sling, car seat or capsule, stroller or pram, highchair, bouncer, jolly jumper or play pen?"*, and *"When thinking about each occasion that your child was in one of those devices, how long were they usually in it?"*. Given that the infant movement guidelines recommend not restraining an infant for more than 1 hour at a time [48], with response options of "less than 15 minutes per day", "between 15 and 30 minutes per day", "between 30-35 minutes per day", and "between 45 to 60 minutes per day" were combined to indicate the proportion of parents compliant with this recommendation. Screentime behaviors were explored by asking participants two surveys items: *"Thinking about the past week, on a typical day, how much time did your child spend watching televisions programs, videos/internet clips or movies on a televisions, computer or portable/mobile device such as iPad, tablet or smartphone?"* (i.e. passive screentime) and *"Thinking about the past week, on a typical day, how much time did your child spend playing games, looking at photos, or video chatting (e.g. FaceTime, Zoom, Skype) on a screen-based device such as a computer or laptop, video games console, iPad, tablet, or smartphone?"* (i.e. interactive screentime). Response options ranged between "0 minutes per day" to "more than 2 hours per day". Given Australian 24-hour movement guidelines recommend no screentime for children under 2 years of age [48], if a parent responded "0 minutes per day" to screentime items, they were coded as "not offering any screentime per day" indicating the proportion of children meeting screentime guidelines. These items were only assessed within the 12-month survey.

Parental Mental Wellbeing at 12 months

The Short Warwick Edinburgh Mental Wellbeing Scale (SWEMWBS) was used to capture parental mental wellbeing [49]. The SWEMWBS was funded by the Scottish Executive National Program for improving mental health and wellbeing, commissioned by NHS Health Scotland, developed by the University of Warwick and the University of Edinburgh, and is jointly owned by NHS Health Scotland, the University of Warwick and the University of Edinburgh [50]. The SWEMWBS is a 7-item tool that has been positively worded to measure participant thoughts and feelings related to functioning over the past 2 weeks. The SWEMWBS is scored by summing the scores for each of the seven items (scored 1 "none of the time" to 5 "all of the time"), and then transformed into metric scores using the SWEMWBS conversion table [49]. Scores can range from 7 to 35, with higher scores indicating higher positive mental wellbeing, and has been shown to be a valid and reliable measure of mental well-being among caregivers [51]. The SWEMWBS was assessed within the 12-month survey only.

Participant Demographics and Pregnancy Characteristics

Within the survey, birthing parents were asked questions related to: Aboriginal and/or Torres Strait

Islander origin; country of birth; residential postcode; current employment status (full-time, part-time, casual, paid or unpaid maternity leave, unemployed, home duties, studies, retired, full-time carers, unable to work due to health problems); timing of their return to work after birth (in months); and the child's date of birth. The survey items are based on those used in previous surveys with post-partum women [52]. Participant education status, first or subsequent pregnancy status, and maternal age data had been collected via previous surveys or medical record data. Participant residential postcode was used to determine geographical remoteness ("major cities" or "regional or remote") using the Accessibility/Remoteness Index of Australia [53]. Postcode was also used to determine socioeconomic areas ("most disadvantaged" or "least disadvantaged") using 2016 socioeconomic indexes for areas [54].

Data Analysis

Data were analyzed by an independent statistician using SAS statistical software (version 9.3; SAS Institute). Descriptive statistics were used to describe: i) characteristics of the samples; ii) feasibility outcomes; iii) program engagement outcomes; and iv) acceptability outcomes. Chi-square/t-tests were used to compare the characteristics of participants between those who had received HB4HNEKids and those who had not (usual care control).

Sample size calculations were not conducted for this pilot feasibility study [55]. However, to explore the potential impact of the program on child breastfeeding, nutrition and movement behaviors, as well as parental wellbeing outcomes (effectiveness), separate logistic regression analyses were conducted to examine differences between survey respondents that had received the HB4HNEKids program, compared with those who had not (usual care control). At both time-points, an unadjusted and adjusted analyses were conducted. Analyses were adjusted for a range of key participant characteristics including parent age, Aboriginal and Torres Strait Islander status, highest level of education, socioeconomic status and level of remoteness. Dichotomous outcomes were presented as Odds Ratios (OR) and 95% confidence intervals (CI), and continuous outcomes were presented as Mean Differences (MD) and 95% CI. A p-value of <0.05 was considered statistically significant.

Results

Feasibility of delivering HB4HNEKids via routine CFHN care

During the 2.5-year pilot period (October 2021 to July 2024) of the HB4HNEKids program a total of 8501 families across the five CFHN services were eligible to receive the program. A total of 6243 families commenced the program (73.4%), from which 430 families later withdrew, giving a 6.9% drop-out rate. A total of 377,969 messages were sent during the pilot period (average 61 messages per family).

Characteristics of cross-sectional survey participants

Of the 780 birthing parents approached, a total of 383 eligible participants completed the 6-month survey (49% response rate) whereby 26% (n=99) of survey participants had received the HB4HNEKids program. Of the 626 birthing parents approached, a total of 283 participants completed the 12-month survey (45% response rate), from which 37% (n=104) survey participants had received the HB4HNEKids program. The two cross sectional samples were similar in terms of birthing parent's age, education status, socioeconomic status and remoteness of geographical location (See Table 1.). The 12-month sample included a higher proportion of participants identifying as Aboriginal and/or Torres Strait Islander (23%), compared with the 6-month sample (11%). By 12-months the proportion of participants on parental leave had significantly dropped compared with 6-month participants (8% vs. 45%, respectively), with more participants engaged in employment at 12-months (66% vs. 30%, respectively).

Participants who had received HB4HNEKids at the 6-month survey had a higher proportion from 'least disadvantaged' areas and higher proportion residing in major cities compared to usual care control participants. Similar differences between groups were found at 12-months, additionally HB4HNEkids participants had a lower proportion of participants identifying as Aboriginal and/or Torres Strait Islander and a higher proportion of participants who had completed tertiary education.

Table 1. Characteristics of birthing parents who participated in the 6- and 12-month survey, by HB4HNEKids participation

	6-month survey participants			12-month survey participants		
	HB4HNE Kids	Usual care	Overall sample	HB4HNEK ids	Usual Care	Overall sample
n (%)	99 (26)	284 (74)	383 (100)	104 (37)	179 (63)	283 (100)
Age of parent (yrs), Mean (SD)	30.6 (4.9)	30.6 (4.5)	30.6 (4.6)	31.6 (4.0)	30.9 (5.3)	31.2 (4.9)
Age of infant, n (%)						
5 months	2 (2)	5 (2)	7 (2)	-	-	-
6 months	97 (98)	279 (98)	376 (98)	-	-	-
12 months	-	-	-	69 (66)	128 (71)	197 (70)
13 months	-	-	-	30 (29)	41 (23)	71 (25)
14 months	-	-	-	5 (5)	10 (6)	15 (5)
Aboriginal and/or Torres Strait Islander, n (%)						
Yes	8 (8)	35 (12)	43 (11)	10 (10)	56 (31)	66 (23) *****
No	91 (92)	249 (88)	340 (89)	94 (90)	123 (69)	217 (77) *****
Highest level of education, n (%)						
High school or less	21 (21)	79 (28)	100 (26)	18 (18)	57 (32)	75 (27) *****
Tertiary	78 (79)	205 (72)	283 (74)	84 (82)	121 (68)	205 (73) *****
Employment status, n (%)						
Employed	25 (25)	89 (31)	114 (30)	75 (72)	113 (63)	188 (66)
Maternity leave (paid or unpaid)	49 (50)	124 (44)	173 (45)	8 (8)	14 (8)	22 (8)
Unemployed	25 (25)	71 (25)	96 (25)	21 (20)	52 (29)	73 (26)
Socio-economic status, n (%)						
Most dis-advantaged	49 (49)	191 (68)	240 (63) *****	42 (41)	119 (67)	161 (58) *****
Least dis-advantaged	50 (51)	90 (32)	140 (37) *****	61 (59)	58 (33)	119 (42) *****
Level of remoteness, n (%)						
Major city	78 (79)	156 (56)	234 (62) *****	77 (75)	108 (61)	185 (66) *****
Regional or remote	21 (21)	125 (44)	146 (38) *****	26 (25)	69 (39)	95 (34) *****

*****Indicates statistically significant ($p<0.05$) difference for the demographic characteristic between survey participants who had received HB4HNEKids, and those who had not (usual care control group).

Total 6-month sample n=383. Incomplete responses/missing data for: Socio-economic status (n=380) and Level of remoteness (n=380). Total 12-month sample n=283. Incomplete responses/missing data for: Highest level of education (n=280), Socio-economic status (n=280) and level of remoteness (n=280).

Engagement with HB4HNEKids text-message content at 6- and 12-months

Of the survey participants receiving the HB4HNEKids program (n=200), 76% and 83% of participants from the 6-month and 12-month survey respectively, reported that they always or very often read the HB4HNEKids text messages. Participants from the 6-month survey reported spending an average of 7.43 minutes engaged in the text-message content of HB4HNEKids, while participants from the 12-month survey reported an average of 5.83 minutes engaged in the content. In addition, 43% of participants from the 6-month survey and 31% from the 12-month survey reported that they always or very often clicked on the website links provided in the messages (Table 2).

Table 2. Self-reported engagement with HB4HNEKids text-message content and links.

	6-month survey participants	12-month survey participants
	N=96*	N=104
Parent always or very often:		
Read the text messages, n (%)	73 (76%)	86 (83%)
Clicked the website links within the text-messages, n (%)	41 (43%)	32 (31%)
Minutes on average spent engaged in the text-message content and links, mean (SD)	7.43 (7.91)	5.83 (5.52)

*Response data missing for 3 survey participants at 6-months, as those who reported opting out of the HB4HNEKids program were not required to provide data on text-message engagement.

Acceptability of HB4HNEKids

At 6-months and 12-months, most parents reported the program was acceptable (see Table 3), with more than 90% of parents agreeing or strongly agreeing with statements related to the overall acceptability of the program, timing of the messages and message content. More than 80% of parents found the embedded website links acceptable.

Table 3. Acceptability of the HB4HNEKids text-messaging program.

AIM	Item	6-month survey. Agree or strongly agree (%)	12-month survey. Agree or strongly agree (%)
		N=96*	N=104
The overall program	Overall, I liked the HB4HNEKids program	93%	95%
	Overall, the HB4HNEKids program meets my approval	96%	94%
	Overall, the HB4HNEKids program was appealing to me	-	90%
	Overall, I was satisfied with the HB4HNEKids program	97%	93%
	I would recommend the HB4HNEKids program to other parents/carers	94%	93%
Text-message timing	I was happy with the timing of the delivery of the content of text messages based on [child] age and development	97%	99%
Text-message content	I found the immunization and growth check reminder text	95%	91%

	messages acceptable		
	I found the information and advice on breastfeeding/formula feeding acceptable	95%	90%
	I found the information and advice on introduction to solids acceptable	95%	90%
Linked resources	I like the website links	84%	86%

*Response data missing for 3 survey participants at 6-months, as those who reported opting out of the HB4HNEKids program were not required to provide data on program acceptability.

Potential effectiveness

Breastfeeding status, breastfeeding duration, introduction to solids and breastfeeding self-efficacy

The proportion of parents currently breastfeeding was not significantly different based on whether the parent had participated in the HB4HNEKids program or not, at both time-points (6-months and 12-months). However, at both time-points, HB4HNEKids participants reported a 5% higher point prevalence of breastfeeding compared with the comparison group participants. There was no difference in breastfeeding duration for HB4HNEKids participants compared with comparison participants. Similarly, there were no statistically significant differences between HB4HNEKids and comparison participants at both time points for mean age of solids introduction and breastfeeding self-efficacy scores (See Table 4 and 5).

Table 4. Breastfeeding and infant feeding outcomes measured at 6 months by HB4HNEKids participation

	HB4HNEKids	Usual Care	Unadjusted estimate (95% CI), *P*-value	Adjusted estimate† (95% CI), *P*-value
Proportion currently breastfeeding, n (%)	61 (66%)	166 (61%)	OR: 1.23 (0.75 to 2.03), *P*=.41	OR: 1.07 (0.62 to 1.83), *P*=.81
Breastfeeding duration in months, mean (SD)	3.80 (2.19)	3.86 (2.15)	MD: -0.06 (-0.57 to 0.46), *P*=.83	MD: -0.17 (-0.69 to 0.35), *P*=.53
Age in months child was introduced to first solid foods, mean (SD)	5.36 (0.80)	5.32 (0.87)	MD: 0.04 (-0.16 to 0.24), *P*=.70	MD: 0.06 (-0.14 to 0.27), *P*=.55
Breastfeeding self-efficacy score, mean (SD)	57.38 (12.72)	55.96 (14.36)	MD: 1.41 (-1.90 to 4.73), *P*=.40	MD: 1.30 (-2.12 to 4.73), *P*=.45

† Adjusted analysis was adjusted for participant socioeconomic status, level of remoteness, level of education, Aboriginal and Torres Strait Islander status and age.
OR: Odds Ratio; MD: Mean Difference; SD: Standard deviation

Table 5. Breastfeeding and infant feeding outcomes measured at 12 months by HB4HNEKids participation

	HB4HNEKids	Usual Care	Unadjusted estimate (95% CI), *P*-value	Adjusted estimate† (95% CI), *P*-value
Proportion currently breastfeeding, n (%)	46 (46%)	68 (41%)	OR: 1.23 (0.74 to 2.03), *P*=.43	OR: 1.07 (0.62 to 1.87), *P*=.80
Breastfeeding duration in months, mean (SD)	3.07 (2.59)	3.24 (2.45)	MD: -0.18 (-0.80 to 0.45), *P*=.58	MD: -0.37 (-1.03 to 0.29), *P*=.27
Age in months child was introduced to first solid foods, mean (SD)	5.59 (1.02)	5.52 (1.02)	MD: 0.06 (-0.18 to 0.31), *P*=.61	MD: 0.02 (-0.24 to 0.29), *P*=.87
Breastfeeding self-efficacy score, mean (SD)	55.48 (15.77)	55.89 (15.34)	MD: -0.40 (-4.30 to 3.50), *P*=.84	MD: -0.73 (-4.82 to 3.37), *P*=.73

† Adjusted analysis was adjusted for participant socioeconomic status, level of remoteness, level of education, Aboriginal and Torres Strait Islander status and age.
OR: Odds Ratio; MD: Mean Difference; SD: Standard deviation

Child nutrition at 12 months

Child daily intake of vegetables serves was significantly higher in the HB4HNEKids group in both the unadjusted (MD: 0.21 (95% CI: 0.05, 0.36), *P*=.009) and adjusted analysis (MD: 0.23 (95% CI: 0.07, 0.40), *P*=.006) compared with the comparison group. Child daily intake of fruit serves was significantly higher in the HB4HNEKids group compared with the comparison participants in the unadjusted analysis (MD: 0.28 (95% CI: 0.05, 0.50), *P*=.015), however this result did not remain statistically significant in the adjusted analyses (MD: 0.20 (95% CI: -0.04, 0.45), *P*=.1). There was no difference in the frequency of child discretionary food intake per week between the groups (See Table 6).

Child movement at 12 months

There were no statistically significant differences between HB4HNEKids participant and comparison participant responses related to child movement behaviors (See Table 6).

Parental mental wellbeing at 12 months

Parents who had received the HB4HNEKids program reported statistically significantly better mental wellbeing scores in the unadjusted (MD: 1.93 (95% CI: 0.94, 2.92), *P*<.001) and adjusted analyses (MD: 1.52 (95% CI: 0.47, 2.58), *P*=.005), compared with the comparison participants (See Table 6).

Table 6. Child nutrition, child movement and parental mental wellbeing outcomes measured at 12 months by HB4HNEKids participation

	HB4HNEKids	Usual Care	Unadjusted estimate (95% CI), *P*-value	Adjusted estimate† (95% CI), *P*-value
Daily intake of fruit serves,	2.07 (1.01)	1.79 (0.88)	MD: 0.28 (0.05 to 0.50), ***P*=.015**	MD: 0.20 (-0.04 to 0.45), *P*=.1

mean (SD)				
Daily intake of vegetable serves, mean (SD)	0.74 (0.70)	0.53 (0.59)	MD: 0.21 (0.05 to 0.36), ***P*=.009**	MD: 0.23 (0.07 to 0.40), ***P*=.006**
Frequency of discretionary food intake per week, mean (SD)	0.99 (0.93)	1.17 (1.03)	MD: -0.18 (-0.42 to 0.06), *P*=.15	MD: -0.02 (-0.27 to 0.23), *P*=.88
Proportion meeting physical activity guidelines, n (%)	88 (85%)	139 (78%)	OR: 1.69 (0.88 to 3.25), *P*=.12	OR: 1.71 (0.84 to 3.48), *P*=.14
Proportion meeting restrained time guidelines, n (%)	70 (72%)	131 (82%)	OR: 0.57 (0.31 to 1.05), *P*=.07	OR: 0.62 (0.33 to 1.18), *P*=.15
Proportion meeting screentime guidelines, n (%)	24 (24%)	48 (27%)	OR: 0.86 (0.49 to 1.51), *P*=.61	OR: 0.63 (0.34 to 1.16), *P*=.14
Parental mental wellbeing scores, mean (SD)	26.15 (3.37)	24.22 (4.43)	MD: 1.93 (0.94 to 2.92), ***P*<.001**	MD: 1.52 (0.47 to 2.58), ***P*=.005**

†Adjusted analysis was adjusted for participant socioeconomic status, level of remoteness, level of education, Aboriginal and Torres Strait Islander status and age.
OR: Odds Ratio; MD: Mean Difference; SD: Standard deviation

Discussion

Principal Results

This study sought to evaluate the feasibility, engagement and acceptability of the pilot HB4HNEKids program, and explore its potential effectiveness on a range of child and parental health and wellbeing outcomes including breastfeeding, child nutrition, child movement and parental mental well-being. Findings indicated that the program was feasible to deliver to families in HNELHD via CFHN services and is met with high acceptability and strong engagement from parents. Further, the evaluation found that the program was likely effective in improving child vegetable intakes, and parental mental wellbeing at 12-months. These findings provide support for further development and improvement of the program with formal testing as part of a larger RCT.

Comparison with Prior Work

This pragmatic evaluation demonstrates that the 1-4-week CFHN service visit (attended by >80% of families in HNELHD) is a feasible way of enrolling new families into a mHealth program, at scale. There remains scope to further optimize the reach of HB4HNEKids, given just 73.4% of eligible families coming through the pilot CFHN services were enrolled into the program. However, the

initial reach of the HB4HNEKids program appears relatively high in contrast with other digital health interventions (DHIs), with systematic reviews of DHIs reporting a median reach of just 21.8-33.6% [56]. Engagement is another critical factor in determining the success of DHIs, with systematic review evidence suggesting that engagement is associated with a variety of improved health behaviors including fruit and vegetable intake, weight status, smoking and physical activity [57-59]. Our results indicate good participant engagement with the HB4HNEKids program, with most HB4HNEKids participants reporting that they ‘always’ or ‘very often’ read the text-messages, spending on average 6 minutes interacting with each message. While a systematic review by Grady et al.[60] found text-messages are a key DHI design feature associated with engagement, the extensive co-design process undertaken in the design of the HB4HNEKids program may also be driving strong engagement rates [61]. This combined with low opt-out rates and high parent reported acceptability, the HB4HNEKids program holds significant promise for reaching and engaging parents in health promotion content during the first 2000 days.

Vegetable intake is a key indicator of a healthy diet providing an important source of essential vitamins and minerals [62]; however, only 18.5% of Australian children aged 2-3 years meet the recommended intake for vegetables, dropping to just 3.8% in children aged 4-8 years [63]. Although data collected from parents within the HNE region of NSW Australia indicates that 12-month-old children are not meeting the recommended serves of vegetables each day (2-3 serves), the evaluation indicates that children from families who were receiving HB4HNEKids were having 0.23 of a serve more vegetables per day than families in the usual care group. This finding is promising, given that increased vegetable intake is associated with a reduced risk micronutrient deficiency [64] and non-communicable diseases in adulthood [65]. Therefore, future research to assess the sustainment of the program’s effects over time are warranted, to better quantify the child and population level benefit of the HB4HNEKids program.

Like other trials such as the original Health Beginnings RCT [27], our evaluation did not indicate a statistically significant difference in current breastfeeding rates between the HB4HNEKids and usual care participants. These findings are inconsistent with those of a recent systematic review of text-message based interventions, with meta-analyses showing they were effective at improving exclusive breastfeeding rates particularly when they engage families in the prenatal period [26]. However, given our pilot study was not powered for this outcome and still observed a 5-point prevalence difference in current breastfeeding rates (favoring HB4HNEKids participants) at 6-months and 12-months, this result is nonetheless highly encouraging. Even so, further development and optimization of the breastfeeding content offered within the program, or expanding the program to engage families earlier (i.e. antenatally) could be of value.

In contrast with the original Healthy Beginnings RCT that found families receiving text-message support (combined with accompanying printed resources) were significantly more likely to ‘never have screen time’ compared with the control (adjusted OR: 1.28 (95% CI: 1.08-1.52), $P<.05$) [27], our evaluation did not indicate any differences between HB4HNEKids and usual care participants screentime behaviors or any other movement behaviors at 12-months. While the text-message content of the HB4HNEKids program related to child screentime and movement behavior during the first 12-months mirrored that of the original Healthy Beginnings text-message content and focused on increasing parental knowledge of child movement and screentime guidelines (e.g. one message on movement guidelines, one message on restrained time guidelines and one message on screentime recommendations), the omission of the booklet content from HB4HNEKids could be driving this difference. However, given that formative research suggests parents would prefer to be engaged in content focused on the benefits of certain movement and screentime behaviors, rather than the risks [66], there remains opportunity to strengthen parent directed text-message content to better address

known barriers and facilitators to child screentime and movement behaviors during the first 12-months.

The perinatal period demands significant emotional, psychological, social and physical adaptation from parents, and represents a period of change that can have implications on parental wellbeing and mental health outcomes. Parental mental health and wellbeing are of key importance during this early life stage, as it can influence parent-child relationships, the quality of care provided, and in turn the child's life trajectory [67-69]. Outside of the standardized mental health screening conducted by primary care services, there is limited support embedded within health services to generally support parental wellbeing [70, 71]. Thus, the improved mental-wellbeing scores at 12 months among those receiving the program compared with those who did not (MD: 1.51 (95% CI: 0.45, 2.57), p=0.005), is important.

Limitations

The results of this evaluation must be considered within the context of our study limitations. These include the use of our convenience sampling methods, which included only a small subsample of participants who had received the HB4HNEKids program, thus not providing data that is representative of the whole HNE region. Further, given the cross-sectional nature of our evaluation, and that HB4HNEKids and comparison participants were not randomly allocated, we cannot be certain the differences in child vegetable intakes and parental mental wellbeing outcomes are explicitly due to the text-messaging program [72]. Further, most of the outcomes assessed within this evaluation were self-reported by participants and may be influenced by self-report, social desirability or recall biases. However, where possible, validated survey tools were used. This pilot study was not powered to detect a statistically significant differences between groups for many of the outcomes assessed, including proportion currently breastfeeding and proportion of children meeting physical activity guidelines. The HB4HNEKids program is currently operating as a complimentary mHealth program alongside an existing routinely offered health service. The insight offered through this evaluation of a real-world health service intervention (while acknowledging the limitations stated) would be strengthened with the opportunity to evaluate the program using more robust methodologies and a larger sample size.

Conclusions

This evaluation of the pilot HB4HNEKids text-messaging program indicates that the program is feasible to deliver at scale, along-side routine CFHN care and is highly acceptable and engaging to parents. Our findings indicate possible efficacy of the program for improving child vegetable intake and parental mental wellbeing at 12 months. However, further evaluation of the program within larger representative samples using robust methodology are needed to determine the true impact of this innovative program.

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Conflicts of Interest

None declared.

Abbreviations

ANIFS: Australian National Infant Feeding Survey
BSES-SF: Breastfeeding self-efficacy scale short form
CATI: Computer Assisted Telephone Interview
CFHN: Child Family Health Nursing
CI: Confidence Interval
HB4HNEKids: Health Beginnings for Hunter New England Kids
HNE: Hunter New England
HNELHD: Hunter New England Local Health District
MD: Mean Difference
mHealth: Mobile Health
NSW: New South Wales
OR: Odds Ratio
RCT: Randomized Controlled Trial
SWEMWBS: The Short Warwick Edinburgh Mental Wellbeing Scale

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