Views of adolescent patients and their families on the use of digital technology to support health behaviour change in young people under the care of a Complications of Excess Weight service

Emma Alice Webb, Bonnie Teague, Matt Farrar, Victoria Farrar, Dorothy Szinay, Li F Chan, Ken, K Ong, Ben Jackson, Felix Naughton, Jon Wilson, Sydney Wylie, Emma Alice Webb

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Table of Contents

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Emma Alice Webb[1, 2] BSc, MBBS, PhD; Bonnie Teague[1, 3]; Matt Farrar[4]; Victoria Farrar[4]; Dorothy Szinay[5]; Li F Chan[6, 7]; Ken, K Ong[8]; Ben Jackson[9]; Felix Naughton[5]; Jon Wilson[1, 3]; Sydney Wylie[10]; Emma Alice Webb[1, 2] BSc, MBBS, PhD

[1]Norwich Medical School Norwich GB
[2]Jenny Lind Children's Hospital Norfolk and Norwich University Hospital NHS Foundation Trust Norwich GB
[3]NSFT Research Norfolk and Suffolk NHS Foundation Trust Norwich GB
[4]LovedBy Group Cheshire Chester GB
[5]School of Health Sciences University of East Anglia Norwich GB
[6]Department of Paediatric Endocrinology The Children's Hospital at the Royal London Hospital London GB
[7]Centre for Endocrinology William Harvey Research Institute, Barts and the London School of Medicine, Queen Mary University London GB
[8]MRC Epidemiology Unit & Department of Paediatrics Institute of Metabolic Science, University of Cambridge Cambridge GB
[9]Health Innovation East Cambridge GB
[10]Public Contributor Norwich GB

Corresponding Author:
Emma Alice Webb BSc, MBBS, PhD
Norwich Medical School
University of East Anglia
Norwich
GB

Abstract

Background: The increasing prevalence of paediatric obesity presents a major challenge for healthcare services. In England, Complications of Excess Weight (CEW) clinics provide specialist multidisciplinary care for children presenting with co-morbidities of severe obesity. Positive treatment outcomes require the young person and their family to make behavioural changes to improve the child's health. However, there are many barriers to health behaviour change, particularly for adolescents. Digital technology could be used to enhance the support offered by CEW clinics to adolescent patients to increase the likelihood of successful behavioural change, but little is known about their and their families' views of this.

Objective: We aimed to explore the views of adolescent patients and their families on how digital technology could be utilised by CEW clinics to support health behaviour change.

Methods: The study took a participatory design approach. Four focus groups and co-design workshops were facilitated by a cross-disciplinary team of clinicians, academics and technology innovators. Participants were adolescent CEW clinic patients (aged 10-16 years) and their adult family members. Focus groups and workshops explored young people's health priorities, the barriers and facilitators of health behaviour change, and co-designed ways in which technology could be used to support young people in overcoming these barriers to achieve their health goals. Focus group data were analysed using inductive content analysis, with findings integrated with key co-design workshop outputs.

Results: 37 individuals (19 adolescents, 18 family members) participated across the focus groups and workshops. Participants were in favour of the increased use of digital technology by CEW clinics as an adjunct to in-person support. Weight was not mentioned by participants as an important aspect of their health. Instead, mental health, sleep and peer support were identified as the domains in which adolescent CEW patients felt they would most benefit from additional support and participants reported that technology could be helpful in providing this support. Participants expressed a preference for technology able to individually tailor content to the young person's needs, including relatable peer-produced content. The need for support for both the young person themselves and their family members was highlighted, as well as the need to integrate strategies to maintain engagement with any technological offering.

Conclusions: There is clear potential for digital technology to be used to support the holistic health priorities of young people receiving specialist care for co-morbidities related to excess weight. We plan to use the findings of this study as the basis to begin developing innovative approaches to the use of technology to support this high-need group.

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Brioney Gee[1,2], Bonnie Teague[1,2], Matt Farrar[3], Victoria Farrar[3], Dorothy Szinay[4], Li F. Chan[5,6], Ken K. Ong[7], Ben Jackson[8], Felix Naughton[4], Jon Wilson[1,2], Sydney Wylie[9], Emma A .Webb[2,10]

1. NSFT Research, Norfolk and Suffolk NHS Foundation Trust, Norwich, UK.
2. Norwich Medical School, University of East Anglia, Norwich, UK.
3. LovedBy Group, Cheshire, UK.
4. School of Health Sciences, University of East Anglia, Norwich, UK.
5. Centre for Endocrinology, William Harvey Research Institute, Barts and the London School of Medicine, Queen Mary University, London, UK.
6. Department of Paediatric Endocrinology, The Children's Hospital at the Royal London Hospital, London, UK.
7. MRC Epidemiology Unit & Department of Paediatrics, Institute of Metabolic Science, University of Cambridge
8. Health Innovation East, Cambridge, UK.
9. Public contributor
10. Jenny Lind Children's Hospital, Norfolk and Norwich University Hospital NHS Foundation Trust, Norwich, UK.

Corresponding Author: Dr Emma Webb, Floor 2, Bob Champion Research and Education Building, James Watson Road, University of East Anglia, Norwich Research Park, Norwich, UK. NR4 7UQ; emma.webb@nnuh.nhs.uk

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Abstract

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expressed a preference for technology able to individually tailor content to the young person's needs, including relatable peer-produced content. The need for support for both the young person themselves and their family members was highlighted, as well as the need to integrate strategies to maintain engagement with any technological offering.

Conclusion: There is clear potential for digital technology to be used to support the holistic health priorities of young people receiving specialist care for co-morbidities related to excess weight. We plan to use the findings of this study as the basis to begin developing innovative approaches to the use of technology to support this high-need group.

Keywords: digital technology; health behaviour change; obesity; young people; adolescents; participatory research

1. Introduction

The growing prevalence of childhood obesity is among the most important threats to public health globally [1]. In addition to being at higher risk of significant childhood comorbidities [2], overweight and obese children are more likely to experience obesity in adulthood [3]. Adults with obesity are at markedly increased risk of a wide range of noncommunicable diseases, including cardiovascular diseases, diabetes, musculoskeletal disorders and certain types of cancer [4].

In England, 22.7% of children aged 10/11 years were living with obesity in 2022/23, with 5.7% classed as severely obese [5]. This equates to more than 2.5 million children eligible for specialist treatment according to the National Institute for Health and Care Excellence (NICE) guidance [6]. Obesity costs the NHS around £6 billion annually and, without a significant step-change in health intervention effectiveness, these costs are estimated to rise to over £9.7 billion per year by 2050 [7].

Further, childhood obesity is a significant factor in the maintenance of health inequalities [8]. Children growing up in the least economically advantaged neighbourhoods are more than twice as likely to experience obesity, and four times as likely to experience severe obesity, as their peers growing up in the most advantaged neighbourhoods [5]. Obesity if also more prevalent in children from Black and Asian (excluding Chinese) ethnic backgrounds than in children from White backgrounds [5].

The NHS Long-Term Plan [9] committed to improving the care available to children and young people experiencing health complications related to excess weight. As part of this commitment, 21 new Complications of Excess Weight (CEW) clinics located across England were commissioned in 2021 [10]. CEW clinics provide specialist biopsychosocial care, delivered by a multidisciplinary team comprising consultants, nurses and allied health professionals (e.g. dietician, physiotherapist, psychologist, family therapist, social worker). Given the limited evidence-base for what constitutes optimal care for young people experiencing severe obesity [11], a key objective of

the pilot clinics was to contribute to generating evidence on the most promising interventions and service models for this cohort.

During their treatment, young people under the care of a CEW clinic are encouraged to make multiple behavioural changes to improve their health, such as increasing activity, changing dietary patterns and taking regular medication. However, adolescents face multiple barriers to successful and sustained behavioural change [12]. Whilst CEW clinicians aim to support young people and their families to overcome these barriers, this support is only provided during scheduled clinic appointments.

Digital technology is now an integral component of almost all young people's lives [13]. As such, increased use of digital technology may enable CEW clinics to offer their patients accessible ongoing support between appointments to increase the likelihood of successful health behaviour change. Systematic reviews of technology-based interventions for overweight and obesity in adolescents have found some evidence of short-term improvement in dietary behaviours and physical activity [14], and significant reductions in body mass index (BMI) [15–17].

However, while short-term engagement with technology-based behaviour change interventions is often good, this engagement tends to decrease over time [18–20], likely limiting their impact [21]. Further, despite the acknowledged importance of involving intended end users in the development of digital health technologies [22], most currently available digital weight-management interventions were not developed with the involvement of patients or health care professionals [23].

This study aimed to explore the views of young patients and their family members on the potential for digital technology to enhance the support offered by CEW clinics to adolescents with severe obesity. Research questions we sought to address included: (a) what are the most important unaddressed health priorities for adolescent CEW clinic patients from the perspective of patients and their family members? (b) what do adolescent CEW clinic patients and their family members perceive to be the key barriers and facilitators to health behaviour change, and to what extent do they

believe that digital technology could assist in overcoming barriers? (c) what preferences do adolescent CEW clinic patients and their family members have for the design and delivery of digital technology to support health behaviour change?

2. Methods

Design

The study used a participatory design involving a series of focus groups and co-design workshops (see Figure 1) with adolescent CEW clinic patients and their adult family members. Each focus group/workshop was run twice on the same day to facilitate a larger number of families to participate whilst maintaining small group sizes (maximum 5 young people and five parents/guardians) to encourage participants to feel comfortable sharing their views openly. Focus group one and workshops one and two were run as an iterative process with analysis of session one being used to inform discussion in the subsequent workshops. The same group of families participated in the first three sessions (focus group 1 and workshops 1 and 2). The final focus groups (focus group 2) reviewed the conclusions of focus group 1 and workshops one and two. For the final focus groups, a different group of young people were recruited.

All focus groups and workshops were carried out face-to-face at non-clinical venues to maximise engagement. Each session lasted approximately 90 minutes. The study was carried out over a 12-month period from January-December 2023.

[Insert Figure 1]

Setting and participants

The Healthy Futures clinic at Norfolk and Norwich University Hospital (NNUH) was established in 2022 as one of 21 pilot CEW clinics commissioned by NHS England. The clinic provides specialist medical, dietetic, psychological and family support to around 100 new patients each year. Children and young people eligible for the service are aged between 2 and 17 years, have a BMI 3.5 standard deviations above the mean, and a suspected or diagnosed physical (e.g. hypertension, joint or mobility problems, abnormal glucose metabolism, fatty liver disease, sleep apnoea) or psychological co-morbidity.

Young people eligible to participate were patients of the NNUH CEW clinic aged 10-16 years, who were willing and able to provide informed consent/assent to participate (and for those aged under 16, whose parent/carer was willing and able to provide informed parental consent for their participation). Participating family members were consenting adult caregivers (aged 18+) of eligible young participants, largely parents/carers but also including a small number of other relatives (i.e., grandparents, adult siblings).

Each family was offered £50 in high street shopping vouchers per focus group or workshop they attended, and reimbursement of any travel expenses, in recognition of the time and effort involved in their participation.

As the study used a qualitative methodology, a formal sample size calculation was not appropriate. Instead, the sample size was selected with regard to empirical guidance regarding the number of focus groups and participants needed for a high likelihood of reaching theoretical saturation [24], while also taking into account pragmatic considerations such as the timeframe of the study and resources available.

Focus groups

Focus groups were facilitated by authors BG and BT, both clinical researchers experienced in facilitating focus groups regarding sensitive topics with young people and their families. In addition, one or more members of the CEW clinical team was present at each focus group and available to

support participants. Focus groups were semi-structured with content guided by approved topic guides, supported by visual aids presented via a slide deck. Each participant was provided with a notepad and encouraged to write or draw their ideas if they felt more comfortable communicating their views in this way than contributing verbally.

Topic guides were informed by the COM-B model of behaviour change [25], which identifies three factors – capability, opportunity and motivation – as necessary for successful behaviour change. Topics covered in focus group 1 included: (a) participants' understanding of what 'living a healthier life' means, (b) perceived barriers to and facilitators of making changes towards a healthier life, and (c) what additional support participants believed young people accessing a CEW clinic would benefit from to help them to make changes towards a healthier life (including the potential role of technology in providing this support).

Topics covered in focus group 2 included: (a) the extent to which participants agreed with the health domains prioritised in previous focus groups/workshops as the most important unaddressed needs for CEW clinic patients, (b) participants' views of existing digital health technologies designed to support the health domains prioritised in previous focus groups/workshops, (c) participants' views of existing health technology platforms through which young people accessing a CEW clinic could be provided with access to additional digital support. The technology platforms presented were chosen based on the priorities young people had highlighted in the preceding focus groups and workshops.

All focus groups were audio recorded and transcribed by members of the research team. All written/drawn contributions were collected and transcribed and/or photographed.

Co-design workshops

Creative co-design workshops were facilitated by authors MF and VF, experienced technology design professionals at LovedBy with prior experience of working in collaboration with

adolescents to co-design digital health behaviour change interventions. In addition, as with the focus groups, one or more members of the CEW clinical team was present at each workshop to support participants as required.

Workshop content was designed to encompass the first two stages of the Design Council's Double Diamond design process [26]: the 'discover' phase, involving gaining a detailed understanding of the design problem to be addressed through close engagement with the experiences and views of those impacted, and the 'define' phase, involving using the insights gathered during the discovery phase to clearly define the design challenge and develop hypothesised solutions to be tested an refined in future phases. Activities involved emotional journey mapping of the young person's day, paper-based co-creation exercises, initial prototyping of ideas generated, and gathering feedback on potential design solutions.

Due to the creative and non-linear nature of the workshops, these were not audio recorded. Instead, the research team made observational field notes to capture key discussions and collected or photographed all written and visual outputs (i.e., notes, drawings, diagrams) produced by participants during the sessions.

Data analysis

Since co-design involves collaborative real-time identification of challenges and co-creation of solutions between workshop participants and researchers [27], analysis in co-design is not a discrete process occurring after data collection is complete. Instead, initial phases of analysis take place concurrently with data generation through a collaborative process of participants and researchers working together to agree the focus and outputs of the co-design process [28]. Analysis of the focus groups followed more conventional qualitative data analysis procedures. This involved inductive content analysis [29,30] of focus group transcripts, involving data familiarisation, iterative coding, and creating and refining content categories and subcategories.

Following completion of the co-design process and inductive content analysis, the workshops outputs and focus groups findings were reviewed and synthesised to generate overall answers to each of the study's research questions. This process included mapping findings to the COM-B model and Theoretical Domains Framework of behaviour change techniques [31] to support identification of potential intervention components.

Patient and Public Involvement

A young person with personal experience of being supported by a CEW clinic acted as a Young Advisor and was an integral member of the study team. SW was involved in developing the recruitment strategy, advised on topic guides and workshop schedules, attended focus groups and workshops, and contributed to interpretation and dissemination of findings. She is a co-author of this manuscript and her reflections on being involved in the study are included as Textbox 1.

Ethical considerations

The study was approved by the NHS Health Research Authority following a favourable ethical opinion from Wales Research Ethics Committee (REC) 4 (Ref: 22/WA/0340). Informed consent (or informed parental consent and the young person's assent in the case of those aged under 16 years) was obtained and documented prior to participation in the study.

3. Results

In total, 19 young people and 18 family members (N=37) took part in the study; 25 in the first set of focus groups and workshops, 13 in the final focus groups (one young person was part of both cohorts). Across both cohorts, the mean age of young participants was 13.4 years (range 10-16, SD=1.68), mean BMI SDS was 36.6 (range 34-47, SD 0.3), 11 were female and 8 male, and all were white except for one participant who identified as Asian. Based on participants' home

postcodes, mean socioeconomic decile was 4.3 (range 1-8, SD 2), seven participants and their parents/guardians came from the lowest 3 socio-economic deciles. No demographic data were collected for family members.

Research question 1: What are the most important unaddressed health priorities for adolescent CEW clinic patients and their family members?

When asked to define what living a 'healthy life' meant to them, participants' responses fell into three categories: achieving good mental health, implementing healthier behaviour patterns, and having positive health outcomes. The category of achieving good mental health encompassed feeling happy and "good in yourself" as well as feeling confident and satisfied with their appearance. Health behaviours viewed as important to living a healthier life included eating a healthy diet, building exercise or other enjoyable activity into their daily lives, and regularly getting enough sleep. Health outcomes participants mentioned wanting to achieve included having more energy and living longer. Losing weight or maintaining a healthy weight was not mentioned by participants as an important aspect of health except as it related to the above categories.

Three domains emerged as the areas both young people and their family members viewed as being the most important health priorities for which there is not currently adequate support available: mental health, sleep and peer support.

Mental health was viewed as the most important unaddressed health priority by nearly all young people and their family members. The mental health support currently available was often viewed as inadequate due to difficulties accessing specialist mental health services and long waitlists for treatment.

"persistent [mental health] problems I like wrote about and described to like doctors for years, nothing happens because the waitlists are that long… I think it's the thing I'd like to see the most done about, because there seems to be the worst area in my experience" (Young Person)

"she's had two referrals to CAMHS [child and adolescent mental health services] and they've both been rejected both times. And they're when we've been right at the worst moments as well. And that's where you need the support" (Family member)

Participants spoke about schools as often being the only source of mental health support available to them. The quality of the mental health support provided by schools was described by participants as highly variable. Some families were highly satisfied by the support they had received from their child's school. However, others were less than satisfied by the support available; several reported that the responsibility for pastoral support in their school fell to staff with little training in mental health who were therefore ill-equipped to provide the specialist support they/their child needed.

Mental health was viewed as foundational to all other aspects of health, with poor mental health reducing the young people's ability to engage in the process of health behaviour change.

"well for me mental your mental health is key, isn't it? You're happy. Everything else falls into place. Then it's come to light that if your if your mental health isn't great, and then everything else drops off, you know" (Family member)

Sleep was also viewed as an important area of unmet need by some young people. This emerged particularly strongly in the emotional journey mapping activity (Figure 2), during which young people and their family members highlighted the impact of poor-quality sleep on the young person's daytime mood, energy and functioning. The young person's mood and ability to function (for instance, to attend school regularly and on time) in turn impacted the wellbeing of the wider family. None of the participants reported having previously received professional support focused specifically on sleep, but some had tried using self-help resources with varied success.

"She found it so difficult to sleep. We've tried all sorts, at the minute she's listening to Whale noises and stuff like that just to try and block everything else what's going on in her head to go to sleep. But

even then, sometimes that's not working and it's difficult for her. And then when it comes to school, it's like 'I can't go to school. I don't wanna go to school'." (Family member)

The final area of unmet need highlighted by participants was peer support. Peer support was seen as an important factor in helping young people successfully change their behaviours, good peer support was also seen as a protective factor for mental health. This was seen as important by nearly all adult family members. Young people were more divided on the importance of this area depending on the quality of their existing friendships. Some young people were satisfied with the support provided by their existing friendships and therefore did not view peer support as something from which they would benefit.

"I've always had like really helping like relationships with my friends and my family and that… if I didn't have friends, I don't know how will it feel" (Young person)

However, others described having few friendships and finding it hard to relate to peers.

"I've had worse than everyone who I've been in my school with, so there's no point in asking how they feel" (Young person)

Experiences of bullying and neurodiversity were viewed as key barriers to young people forming supportive peer networks.

The opportunity to meet people facing similar challenges was viewed as being potentially beneficial both for the young people themselves, and for their family members.

"at school I think young people are so judged by what they look like. And I think that [opportunities for peer support] would kind of make them not feel as bad. Yeah, if you know what I mean. Because they've got the support, and they'll realise that they're not the only one who struggles" (Family member)

Adult participants fed back that they had valued the opportunity to do this during the focus groups and workshops and would appreciate further opportunities to connect with parents/carers in similar situations to themselves.

Research question 2: What do adolescent CEW clinic patients and their family members perceive to be the key barriers and facilitators to health behaviour change, and to what extent do they believe that digital technology could assist in overcoming barriers?

Poor mental health was cited as a significant barrier to health behaviour change. Anxiety related to social interactions and engagement in group health activities, sometimes related to previous experience of bullying and/or low self-esteem were viewed as particularly problematic. Poor sleep was also noted as impacting on motivation to engage in health behaviour change. Disruption to routines, for instance due to school holidays, and seasonal pressures such as Christmas, Easter and summer breaks, were viewed as making in more difficult to maintain healthy behaviours. Financial considerations were also important barriers to health behaviour change for many families. The high cost of healthy food and activities, and limited access to affordable transport, particularly for those living in rural areas, were the main financial barriers raised by participants.

"I was trying to find, you know, the money to go and do lots of [active] things, do those things. Time is not an issue… I can give her the time that she needs. Yeah, it's whether I've got the funds to do it." (Family member)

Social support was viewed as the most important facilitator of health behaviour change. The support and encouragement of family was most often seen as imperative, with changes undertaken as a family easier to maintain than those made by the young person in isolation.

"they [family] can encourage you to go out and do like exercise and things like that, and encourage you to eat healthier options, but also they kind of do it as well with you" (Young person)

Support from peers and from school staff were also important facilitators of making and maintaining changes for some participants.

Digital technology was seen both as presenting barriers to, and as potentially helpful in supporting, health behaviour change. The opportunity costs imposed by intensive use of digital

technology was seen as a barrier to health behaviour change, with time spent engaging with screen-based activities (e.g. playing video games, using social media, watching online content) detracting from the time available for physical activity and encouraging snacking behaviour.

"It makes one want to eat as well, you're sat there doing nothing, well looking at screen, you want, yeah, they, they do because…it's like 'oh, I'm sitting here, I can just snack on something'. Whereas if they're out and about, they're not thinking about it." (Family member)

The content young people are exposed to online was also sometimes viewed as creating barriers to health behaviour change. For instance, seeing images of 'ultra-fit' celebrities and influencers in social media was viewed as creating unrealistic expectations, impacting on motivation to change behaviours.

Many young people reported having used health apps, for instance step trackers or food diaries, and having found these helpful, at least to some extent. However, adult family members spoke about the costs associated with some health technologies creating barriers to sustained use, for instance health apps that charge a monthly subscription after an initial free trial period.

"even working families struggling and even having to buy an app, that's maybe only £4.99 but that's £4.99 that's coming out of the food bill" (Family member)

Some aspects of social media were also viewed as facilitators of health behaviour change, both by young people and their family members. Helpful online content families spoke about included inspiring stories of health behaviour change, ideas for healthy recipes, and suggestions of enjoyable movement, particularly activities and challenges that could be done together as a family.

Research question 3: What preferences do adolescent CEW clinic patients and their family members have for the design and delivery of digital technology to support health behaviour change?

Extensive use of digital technology was reported to be a universal aspect of the lives of all the young participants. As such, support delivered or facilitated via technology was viewed as a potentially useful adjunct to face-to-face support. However, participants were also clear that it shouldn't be a replacement for the support currently available, or indeed seen as a substitute for increasing the availability of face-to-face support in areas on unmet need.

Key perceived benefits of using digital technology to provide support were that it can allow for more immediate access than face-to-face support, and that it can give the young person increased privacy and autonomy in relation to the support they receive.

"they can dip in and out of that they can actually access for themselves, yeah, when they need it, when they want it and nobody else knows what they're doing" (Family member)

"I know that [being able to access support via technology] would help me and I know it would definitely help a lot of my friends that can't speak out, and their friends and their like parents won't give them that support" (Young person)

Participants viewed digital technology as having the potential to help address all three of the unmet health priorities identified: mental health, sleep and peer support. The privacy and autonomy offered by digital interventions was viewed as particularly valuable in areas that might be more sensitive, such as mental health. Technology was also seen as a practical way of bringing people with similar experiences together to provide peer support and build a sense of community. As well as facilitating direct content with other families, participants expressed that they would value having access to digital content featuring others who have been through similar experiences. Peer-led content was seen as more relatable than other digital content, lessening feelings of isolation and boosting motivation.

Participants expressed largely positive views of the examples of existing digital health technologies designed to support mental health (Lumi Nova)[32], sleep (digital cognitive behavioral therapy (Sleepio)[33] for insomnia) and peer support (Kooth)[34] they were shown. Suggested

adaptations to the example technologies largely related to the needs or preferences of the specific young person (for example, to make the technology more appropriate for their age-range) rather than CEW clinic users more widely.

Most participants were not previously aware of the example technologies discussed and parents/carers fed back that they often had difficulty finding out about the resources available to them. Participants felt there is a need for a platform bringing together available resources in an easily accessible format. They expressed a preference for a platform that is appealing and appropriate for the targeted age-range and able to tailor content to the specific health needs of individual young people, including relatable peer-produced content.

Participants raised the need to maintain the young person's motivation to engage with a digital platform. It was suggested that this could be achieved through integration with online applications the young person already uses frequently and/or support from family members and clinicians. Family members felt that they would also benefit from access to digital resources and community to support them to support the young person.

Textbox 1. A young advisor's reflections on her involvement in the study

I was interested in getting involved in the project as I need to make some changes to my own health habits. As a young person I think it's a very important project as access to good and accurate advice about health and lifestyle can be hard and daunting. There is often conflicting advice online and things aren't always presented in a way that makes them accessible. It's also not always that young people don't know the information but that they don't know how to act on it. Particularly if there are circumstances outside their control such as living or financial situation. I know people say it doesn't cost money to be healthy but it can definitely help make it easier.

Also, as someone who enjoys programming the technical side of the project interested me to see how an app could be used and how interactive it could be. During the focus groups I found hearing several young people's perspectives interesting. We had different views sometimes on who would be best to provide information and it was good to discuss our ideas and work together to think about what would have the broadest appeal to as many young people as possible.

I think it's important to understand that young people have access to lots of information and that this project needed to focus on what will really draw young people to make changes. For me personally, I would find it most engaging to hear from professionals in short videos/blogs about different topics. I also especially thought the close work with the company, LovedBy, was helpful as they listened to our thoughts and then helped us shape them to what was possible technically.

The challenges I saw with the project were drawing enough information from participants in a short time scale and it would be really good to have follow up sessions even if online as I think people often think of things after the event that would be useful. Success to me on this project would be a resource for young people to find good and accurate information about getting and maintaining a healthy lifestyle. Real advice but with thought about how lifestyles are different for young people depending on their circumstances. Advice on how to make the healthier habits both realistic but also interesting to achieve would be good. Also, a way to set goals and measure achievements within an app/site would encourage people with forming better habits.

During data analysis concepts were mapped under the components of the COM-B model and the constructs of the TDF. Behaviour change techniques were identified to support future work in the development of intervention components. The concepts mapped under these models an the behaviour change techniques identified are presented in Table 1.

Table 1. Recommendation for future intervention development based on the application of the COM-B model and the TDF.

Concept	***COM-B***	***TDF***	***Suggested Behaviour Change Techniques***
Happiness about weight and weight loss journey	AM	Emotions	11.2. Reduce negative emotions
Increasing confidence and their beliefs about being proud of themselves	RM	Beliefs about capabilities	15.1. Verbal persuasion about capability 15.4. Self-talk
Encouraging positive body image and addressing body image	RM SO	Beliefs about capabilities Social identity Social influence	15.1. Verbal persuasion about capability 15.4. Self-talk 3.1. Social support (unspecified) 3.2. Social support (professional) 6.2. Social comparison 9.1. Credible source 13.5. Identity associated with

			changed behaviour
Addressing anxiety, depression, boredom, stress	AM	Emotions	11.2. Reduce negative emotions
Dealing with peer pressure	AM SO PsyC	Emotions Social Influence Behavioural Regulations	11.2. Reduce negative emotions 3.1. Social support (unspecified) 3.2. Social support (professional) 8.2. Behaviour substitution
Addressing being the victim of bullying	AM SO	Emotions Social Influence	11.2. Reduce negative emotions 3.1. Social support (unspecified) 3.2. Social support (professional)
Knowledge and consistent information of what healthy life means: balanced diet, exercise they enjoy, having a healthy sleep pattern, being more energetic; Education on healthy food options, portion size,	PsyC PhyC RM	Knowledge Skills Beliefs about capabilities	4.1. Instruction on how to perform the behaviour 4.2. Information about antecedents 5.1. Information about health consequences 4.1. Instruction on how to perform the behaviour 8.1. Behavioural practice 8.7. Graded tasks 15.1. Verbal persuasion about capability

calories in/out			15.4. Self talk
Addressing the need for professional support	SO	Social influence	3.1. Social support (unspecified) 3.2. Social support (professional)
Addressing the need for group activities, online chat	SO	Social influence	3.1. Social support (unspecified) 3.2. Social support (professional)
Education on what food to shop and to keep at home	PO	Environmental context and resources	3.2. Social support (practical) 7.1. Prompt (cues) 7.5. Remove aversive stimulus 12.1. Restructuring physical environment 12.2. Restructuring social environment 12.3. Avoidance/reducing exposure to cues for the behaviour 12.5. Adding objects to the environment
Support in building and maintaining a routine	PsyC	Behavioural regulation	2.3. Self monitoring of behaviour
Addressing the need for family support	SO	Social influence	3.1. Social support (unspecified) 3.2. Social support (professional)

Addressing the need for exercise support	PsyC SO AM	Behavioural regulation Social influence Reinforcement	2.3. Self monitoring of behaviour 3.1. Social support (unspecified) 3.2. Social support (professional) 10.3. Nonspecific reward 10.4. Social reward
Addressing the role of seasonality (half term, Christmas, Easter)	PsyC SO RM	Behavioural regulation Social influence Beliefs about capabilities Beliefs about consequences	8.2. Behaviour substitution 3.1. Social support (unspecified) 3.2. Social support (professional) 1.2. Problem solving 4.1. Instruction on how to perform behaviour 5.1. Information about health consequences 5.2. Salience of consequences 5.5. Anticipated regret 5.6. Information about emotional consequences 9.2. Pros and cons 9.3. Comparative of imagining future outcomes
Supporting setting	PsyC	Knowledge	4.1. Instruction on how to

realistic expectations	perform a behaviour 4.2. Information about antecedents 5.1. Information about health consequences

Abbreviations: COM-B – Capability, Motivation, Opportunity – Behaviour; TDF – Theoretical Domains Framework; PhyC – Physical Capability; PsyC – Psychological Capability; SO – Social Opportunity; PO – Physical Opportunity; RM – Reflective Motivation; AM – Automatic Motivation

4. Discussion

Principal findings and comparison with prior work

Digital technology offers the potential to provide young people with severe obesity under the care of a CEW clinic with access to additional support between appointments to increase the likelihood of successful health behaviour change. This study aimed to explore the views of young CEW clinic patients and their family members on the use of digital technology to support them in achieving their health priorities.

Young people and their family members were supportive of the idea of increased use of digital technology by CEW clinics to facilitate access to additional support to address currently unmet needs. However, participants expressed the view that this support should be an adjunct to, not a replacement for, face-to-face support provided by clinicians. This view aligns with the evidence-base as there is currently little evidence for the effectiveness of digital interventions for paediatric obesity as standalone interventions outside of a comprehensive package of support [16,35].
When participants were talking about health, they didn't focus on behaviour change that directly affected their weight, but on changes that would help them feel better and would indirectly enable them to engage with behaviour change. Participants identified three domains in which they would particularly benefit from increased support: mental health, sleep and peer support.

Improved mental health, sleep and increased social support (both from peers and family members) were also seen as facilitators of wider health behaviour change, as well as overcoming financial barriers and balancing the benefits of technology against the negative impacts of excessive screen-time.

Many of the barriers and facilitators of health behaviour change refer to by participants in the current study overlap with those identified in a Canadian study of adolescents with severe obesity receiving multidisciplinary clinical care [36]. This study highlighted three factors that impact behaviour change across lifestyle domains: perceived controllability, the impact of mental health and social relationships and interactions. In line with the current study, the Canadian team identified both mental health and sleep as important priority areas for young people living with obesity and concluded that *"lifestyle-based interventions for behavior change should evolve to emphasize outcomes beyond weight status to include mental health as a primary intervention focus and outcome"*.

All three domains prioritised by our participants as unmet needs were areas where technology has previously been found to impact positively on clinical outcomes. Kooth provides a web-based service that gives children and young people access to an on-line community of peers and experienced counsellors [34]. Accessing Kooth is associated with reductions in psychological distress, suicidal ideation, loneliness and reported self-harm. Lumi Nova is a Mobile-App which has been shown to reduce anxiety through delivery of exposure based CBT strategies via immersive gaming technology [32]. Sleepio is a NICE recommended CBT therapy for improving sleep that can be accessed through a website or an App [33].

These existing digital interventions were viewed as potentially helpful but current awareness and utilisation of digital resources was low. Participants expressed enthusiasm for the creation of a platform bringing together digital resources tailored to the needs of individual young people and their

family members, including content created by peers. The use of digital technology to connect young patients and their family members with others with similar experiences was also supported.

In line with previous research [12,17,37], the findings of this study make clear the role of family support in the success or failure of adolescents' health behaviour change efforts. As such, any digital technology developed in this area must take into account the needs and preferences of not just the young patient but their wider family support network.

Strengths and limitations

To our knowledge, this is the first study to seek the views of adolescents under the care of a specialist paediatric obesity clinic and their adult family members regarding the use of digital technology to support health behaviour change. We were able to engage with a diverse range of family characteristics, accessing the clinic through a creative participatory design facilitated by a cross-disciplinary team of clinicians, academics, innovators and a young service-user. The benefits of involving the intended users of a health technology early in the design process are well established [38].

Limitations of the study include it having been conducted in a single site with patients from only one CEW clinic, possibly limiting the transferability of the findings. Further, the geographical area in which this clinic is located (Norfolk, UK) has a population with limited ethnic diversity, which was reflected in the demographics of the sample recruited. However, aligned with the population profile of Norfolk, participating families were from diverse socioeconomic and urban-rural backgrounds. Given the higher prevalence of obesity in young people from non-White ethnic backgrounds [5], it will be important that future research explores the relevance of the current study's findings to families from a diverse range of cultural backgrounds.

Additionally, young people and their adult family members participated in the focus groups and workshops alongside one another. While this was intended to increase the confidence of young

people to participate, it may have inhibited some participants from both groups from expressing their views as openly as they would have if their family members had not been present.

Conclusions

This study highlights the potential for digital technology to be used to provide young people experiencing health complications related to obesity with additional support to make changes to improve their health. The findings suggest that such technology-based interventions should focus on outcomes beyond weight, provide individually tailored content and support the needs of the wider family, not the young patient alone, to maximise their impact. Technological support should be offered as an adjunct to multidisciplinary clinic-based interventions and may require ongoing clinician support to ensure engagement is maintained over time for potential benefits to be realised.

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Conflicts of Interest

EW, BG, BT and JW declare no conflicts of interest.

FN is an unpaid member of the scientific committee for the Smoke Free app

Abbreviations

CEW: Complications of Excess Weight
COM-B: Capability, Opportunity and Motivation Model of Behaviour Change
NICE: National Institute for Health and Care Excellence
NNUH: Norfolk and Norwich University Hospital
REC: Research Ethics Committee

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Figures

Figure 1. Schematic of study design. Focus groups/workshops shown in blue were conducted with the first participant group, those shown in green were conducted with the second participant group.

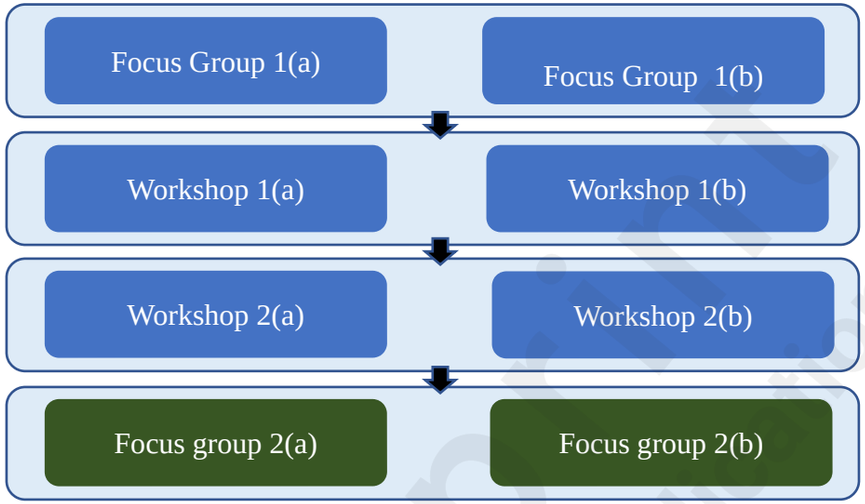

Figure 2. Digital representation of the output of the Emotional Journey Mapping activity carried out in Workshop 1.