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REVIEW

The Potential Role of Digital Health in Obesity Care

Nigel Hinchliffe · Matthew S. Capehorn · Michael Bewick · John Feenie

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ABSTRACT

Obesity is a complex, multi-factorial, chronic condition which increases the risk of a wide range of diseases including type 2 diabetes mellitus, cardiovascular disease and certain cancers. The prevalence of obesity continues to rise and this places a huge economic burden on the healthcare system. Existing approaches to obesity treatment tend to focus on individual responsibility and diet and exercise, failing to recognise the complexity of the condition and the need for a whole-system approach. A new approach is needed that recognises the complexity of obesity and provides patient-centred, multidisciplinary care which more closely meets the needs of each individual with obesity. This review will discuss the role that digital health could play in this new approach and the challenges of ensuring equitable access to digital health for obesity care. Existing technologies, such as telehealth and mobile health apps and wearable devices, offer emerging opportunities to improve access to obesity care and enhance the quality, efficiency and cost-effectiveness of weight management interventions and long-term patient support. Future application of machine learning and artificial intelligence to obesity care could see interventions become increasingly automated and personalised.

Keywords: Obesity; Digital; Telehealth; Artificial intelligence; mHealth

N. Hinchliffe (✉) · J. Feenie
The College of Contemporary Health, Technopark, 90 London Road, London SE1 6LN, UK
e-mail: nigel.hinchliffe@contemporaryhealth.co.uk

M. S. Capehorn
Rotherham Institute for Obesity, Rotherham, UK

M. Bewick
University of Central Lancashire, Preston, UK

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Key Points

Digital health could play an important role in developing a new approach to obesity prevention and treatment that recognises the complexity of obesity and provides a more patient-centred, precision approach to obesity care

Telehealth and mHealth are already widely used in delivering healthcare and they offer emerging opportunities to reduce barriers to effective obesity care, improve access to care and ultimately improve long-term weight management and obesity-related health outcomes

In the immediate future, the most significant digital advancement in obesity care is likely to be the increased use of telehealth. Over time this will be increasingly supported with mHealth apps and devices, with interventions and support ultimately delivered by proxy with an avatar or through a chatbot using AI technology

Creation of a self-contained digital ecosystem for obesity care would likely accelerate the uptake of digital health applications

Digital health solutions have the capacity to improve access to obesity care and reduce health inequalities, but careful consideration is needed to avoid digital health becoming available only to those who can afford the technology or have the digital literacy to take advantage of it; otherwise, existing inequalities will only be exacerbated

INTRODUCTION

Obesity prevalence has almost trebled globally since 1976, with 13% of the world's population (or > 650 million people) now living with obesity [1]. In most developed countries obesity rates are much higher than this, such as the US where > 40% of US adults now have obesity [2] and the numbers continue to rise, particularly in children and adolescents. In the UK, more than a quarter of adults and more than one in five 11-year-olds are now classified as having obesity [3], which puts them at increased risk of associated diseases such as type 2 diabetes, cardiovascular disease and certain cancers [1]. Obesity also reduces quality of life and life expectancy because of morbidity and disability [4–6] and has a negative effect on mental health and social interactions [7]. All of this adds up to a substantial economic burden on society through direct and indirect costs to healthcare systems and lost productivity [8, 9] and requires urgent attention. However, solving the obesity crisis is a huge challenge.

Obesity is a complex condition, with multiple contributing factors [10] and, contrary to popular belief, cannot be solved by simply advising people to reduce food intake and exercise more. The obesity research community is increasingly recognising that obesity is a multifactorial, chronic, relapsing disease requiring long-term management with whole-system support [11], but it is still widely considered to be the responsibility of the individual by governments and healthcare systems [12]. As a result, obesity remains widely misunderstood, and strategies aimed at reducing obesity still tend to rely on interventions with an emphasis on diet and exercise [13, 14]. These interventions are often unsuccessful in the long-term because they do not address the complex nature of the condition [15]. A new approach is needed that recognises the complexity of obesity and provides patient-centred, multidisciplinary care which more closely meets the needs of each individual with obesity [15].

In this review we will discuss the role that digital health could play in this new approach, by helping to address some of the barriers that currently limit the effectiveness of obesity strategies and weight management interventions. This article is based on previously conducted studies and does not contain any new studies with human participants or animals

performed by any of the authors, so no ethics approval was required.

WHAT IS DIGITAL HEALTH?

Digital health is the use of digital technologies to enhance the efficiency of healthcare delivery, make medicine more personalised and precise, and promote health and wellbeing [16]. These technologies can be categorised into genomic testing, digital medicine, artificial intelligence (AI) and robotics and include low-cost sequencing technology, telemedicine, smartphone apps, biosensors for remote diagnosis and monitoring, speech recognition and automated image interpretation [17].

Adoption of digital services within health systems has increased during the COVID-19 pandemic [18, 19], particularly in providing more services remotely, showing the potential for organisations to deploy digital solutions and adapt quickly to new technologies when necessary. The pandemic has also highlighted the need to urgently address the obesity crisis, both in the UK and globally [20]. However, while there has been rapid progress in online and digital tools in the management of a number of diseases, both acute and long-term, including mental health problems [21], diabetes [22] and cardiovascular disease [23], this has yet to be established in obesity care. This may be partly due to embedded cultural bias against obesity and the fact that in many countries, including the UK, it is still not recognised as a disease. Nevertheless, obesity treatment could benefit greatly from the digital transformation of healthcare services, particularly in the areas of telehealth and mobile health, which can offer improved support for, and monitoring of, behaviour change. But it is artificial intelligence which could revolutionise obesity care by enabling real-time patient monitoring and personalisation of interventions. This report will start by reviewing the impact of telehealth and mobile health on obesity care and then go on to discuss the opportunities offered by machine learning and artificial intelligence and other potential future digital health developments.

DISCUSSION

Telehealth/Telemedicine

Telemedicine refers to the use of technology by a healthcare provider to deliver clinical services at a distance [24]. It is often used interchangeably with 'telehealth', although telehealth is a broader term used to describe ways in which technology is used for communication and transfer of information between health professionals and their patients and includes digitisation of medical records, appointment booking, self-symptom checkers and patient outcome reporting as well as remote care [25]. Although telephone is still a common tool for telemedicine, video-conferencing is becoming increasingly common and offers a comparable experience to face-to-face consultations for the patient and clinician.

While we have to recognise the importance of the COVID-19 pandemic in accelerating the adoption of telemedicine, it was already being integrated into healthcare systems pre-pandemic, particularly in the US, where it offers increased access to healthcare in rural and remote communities, and demand continues to increase [26]. That telemedicine has been found to be feasible, accessible, safe and effective in a number of areas of healthcare is probably due to: convenience of appointments, decrease in time commitment for appointments and increasing availability and quality of video-conferencing technology [27].

Telehealth interventions for obesity and weight management tend to be very heterogeneous, so clear conclusions are difficult to draw from the limited research in this area, regarding effectiveness and what components of interventions increase the chances of success (see Table 1). A systematic review of telemedicine interventions for weight loss found they resulted in a reduction in BMI when the duration was at least 6 months [28]. A more recent review of telemedicine for obesity care suggests that telemedicine could help to address a number of barriers to effective obesity treatment. First, it can improve access to specialised obesity care, including multi-disciplinary teams, and it may

Table 1 Systematic reviews of digital interventions for obesity or weight management from last 5 years

Authors/date	Intervention type	Review of	Findings
Huang et al. 2018 [28]	Telemedicine	Effectiveness of telemedicine on BMI	Patients with chronic diseases and/or obesity could benefit from telemed. Interventions, which should be longer than 6 months and emphasise importance of post-interventional follow-ups
Margetin et al. 2022 [32]	Telehealth	Anthropometric outcomes of children and adolescents using telehealth with WM interventions compared to usual care	Low strength of evidence that TH had a small effect on anthropometric outcomes compared to usual care. Future RCTs should be designed to minimise clinical heterogeneity and risk of bias
Patel et al. 2019 [69]	MI in telehealth and eHealth	Motivational interviewing in telehealth and eHealth interventions for WL	Telephone-based interventions incorporating MI hold promise as effective obesity treatments
Shah et al. 2021 [31]	Telemedicine	Randomized controlled trials telemedicine in paediatrics	Telemedicine services for paediatric care are comparable to or better than in-person services. Future research should focus on improving access to care, increasing cost-effectiveness of telemedicine and eliminating barriers to telemedicine use
Whitley and Yahia 2021 [33]	Telehealth	Efficacy of clinic-based telehealth vs. face-to-face interventions for obesity treatment in children and adolescents in USA and Canada	Findings support using TH in conjunction with face-to-face visits for obesity treatment among children and adolescents. More research into telehealth WM interventions for young children is recommended
Antoun et al. 2022 [41]	Mobile health	Effectiveness of combining nonmobile interventions with use of smartphone Apps for WL	Smartphone apps have a role in WM, although the human-based behavioural component remains key to higher WL results
Dounavi and Tsoumani 2019 [40]	Mobile health	Mobile health applications in weight management	MHealth apps are widely considered satisfactory, easy to use and helpful in the pursuit of WL goals by patients. High levels of engagement with apps leads to increased treatment adherence through strategies such as self-monitoring

Table 1 continued

Authors/date	Intervention type	Review of	Findings
Tully et al. 2020 [70]	Mobile health	Mobile health for paediatric WM (scoping review)	Paediatric WM using mHealth is an emerging field. Few large trials are published, and these are heterogeneous in nature. There is an evidence gap in the cost-effectiveness analyses of such studies
Wang et al. 2020 [71]	Mobile health	Effectiveness of mHealth Interventions on diabetes and obesity treatment and management	mHealth interventions are promising, but there is limited evidence of their effectiveness in glycaemic control and weight reduction
Yien et al. 2021 [72]	Mobile health	Effect of mHealth technology on weight control in adolescents and preteens	MHealth technology interventions did not have a significant WL effect on subjects with obesity overall. However, a subgroup analysis showed that BMI of ethnic Chinese groups was significantly lower than that of the control group
Beleigoli et al. 2019 [73]	Digital health	Web-based digital health interventions for WL and lifestyle habit changes in overweight and obese adults	Web-based digital interventions led to greater short-term but not long-term WL than offline interventions. Heterogeneity was high and high attrition rates suggested engagement is a major issue in Web-based interventions
Kouvari et al. 2020 [74]	Digital health	Digital health interventions for WM in children and adolescents	Digital interventions that include parental involvement are functional and acceptable approaches to enhance WL in young populations
Patel et al. 2021 [43]	Self-monitoring with digital health	Self-monitoring via digital health in WL Interventions for adults with overweight or obesity	Self-monitoring via digital health is consistently associated with increased WL in behavioural obesity treatment
Safaei et al. 2021 [75]	Machine learning	Understanding the causes and consequences of obesity and reviewing various ML approaches used to predict obesity	ML methods that can be used for the prediction of obesity. ML can also support decision-makers looking to understand the impact of obesity on health

Table 1 continued

Authors/date	Intervention type	Review of	Findings
Triantafyllidis et al. 2020 [57]	Machine learning	Computerised decision support (CDS) and ML applications for prevention and treatment of childhood obesity	ML algorithms such as decision trees and artificial neural networks can be helpful for obesity prediction purposes. CDS tools can be useful for the self-management or remote management of childhood obesity

mHealth mobile health, *MI* motivational interviewing, *ML* machine learning, *TH* telehealth, *WL* weight loss, *WM* weight management

also be useful for increasing access to treatment for patients with severe obesity who have mobility limitations so have great difficulty travelling to a clinic [27].

Telemedicine requires less time and resource commitments for patients (such as travel costs and time off work), so consultations are easier to attend. Telemedicine can therefore improve adherence to weight management programmes. It also allows for more frequent clinical interactions, which improves the chance of success [29]. What's more, the patient is often in the comfort of their own home, where they feel safe, relaxed and without fear of weight stigma, and the health professional can gain useful insight into the life of their patient—for example, through video, a patient can invite a dietitian to see into their fridge or food cupboard, and the dietitian can see what facilities are available for cooking [27]. A recent review of remotely delivered weight loss interventions concluded that there is accumulating evidence that telemedicine has great potential, demonstrating meaningful clinical improvements in body weight, physical activity and nutrition [30]. Further research is required to establish best practice principles and identify specific patient phenotypes that create successful long-term results from remote obesity care.

Studies of the effectiveness of telemedicine for paediatric obesity paint a similar picture. Systematic reviews of randomised controlled trials comparing telehealth with in-person care show that telemedicine services for paediatric care are comparable to, and possibly more effective than, in-person services but there are high levels of heterogeneity [31–33]. Anecdotally, the use of telemedicine in a multi-disciplinary paediatric weight management clinic in Maine, USA, has demonstrated a number of benefits, which include the fact that patients and family can attend an appointment via telemedicine whilst at different locations (e.g. home, school nurse's office and work during a break) and more members of the interdisciplinary team can provide care remotely from different physical locations. Utilising telemedicine also promotes conservation of resources and efficient use of providers by reducing travel time and reducing weather-related cancellations and 'no-shows'. They view telemedicine as offering a vital bridge to patients in a way traditional in-person visits cannot, providing an opportunity to build trust in their healthcare providers whilst in the safety and comfort of their own homes [24].

There are, of course, potential challenges with implementing telemedicine services, not just for patients but also for providers and health professionals. For patients without broadband or internet access, computers or smartphones, or without the required level of digital literacy, there is a danger the move towards telemedicine may widen existing socioeconomical disparities.

The use of telemedicine in the US during COVID-19 sadly failed to sufficiently address healthcare in communities of the highest need

during the pandemic [34, 35]. Although COVID-19 infections, hospitalisations and deaths were highest among racial and ethnic minorities, telemedicine use was lowest in these communities, where obesity prevalence is often the highest. Reasons for lack of access include insufficient community broadband, no access to a computer or smart device, low digital literacy and being unaware of availability of remote health options [31, 32]. The development of telehealth services for obesity treatment must therefore be informed by the successes and failures of telehealth during the COVID-19 pandemic. Failure to do so risks alienating the populations that stand to benefit most from telehealth for obesity treatment. Without support to access telemedicine and other telehealth services, there is a danger that healthcare disparities will worsen as digital health is expanded [36].

According to a recent report by McKinsey and Company [37], another potential barrier to widening access to telehealth in the US is the attitudes of physicians. According to surveys of patients and physicians in 2021, the majority of patients found telehealth appointments more convenient (60%) and a better experience (55%) than in-person care, while only 36% of physicians find it more convenient and 32% believe it can improve the patient experience. The reasons for this are unclear, but are likely to include a number of factors, from frustration with technology which is unreliable or incompatible with existing digital systems, to lack of confidence due to inadequate training [38] and the costs of implementation. There are also technological challenges for telemedicine providers, most notably in integrating software from a variety of different digital systems [39].

To maximise equitable access to telemedicine for obesity care, healthcare providers need to work with patients, HCPs and telemedicine providers. It will require investment in digital technology and infrastructure, training of HCPs and provision of devices and training for patients when necessary.

mHealth

mHealth (mobile health) is the term used to describe the use of mobile apps, chatbots, social media and wearable devices for healthcare. It is a rapidly evolving area of digital health which is transforming the delivery of behavioural interventions for weight management and the monitoring of diet and physical activity [36].

Health and Care Apps

Research relating to the use of mHealth apps for weight management and obesity care is limited, but systematic reviews of the available evidence suggest that mobile health apps are effective in achieving weight loss and weight loss maintenance and are at least as effective as in-person interventions (see Table 1), although a combination of in-person behavioural therapy supported by smartphone apps may be the most effective [41]. mHealth apps are widely considered satisfactory and easy to use by patients, and their advantage lies in achieving high levels of engagement which increases treatment adherence and ultimately weight loss [40]. They have been shown to successfully deliver behavioural therapy and promote physical activity, dietary changes and self-monitoring of diet, activity and body weight [40, 42]. In fact, digital self-monitoring is associated with greater weight loss compared with non-digital self-monitoring [43]. Further research is needed, particularly to look at the use of apps over longer periods and for maintenance of weight loss and to determine optimal formats and frequency of contact and tailoring of messages.

Most mHealth apps relating to weight management are not designed for use as part of specific interventions; they are designed for the commercial self-care market to help individuals manage their own health and body weight. There are tens of thousands of these apps available and they are very popular, but most are unregulated and untested, so it is difficult for patients to discern which apps are accurate and reliable and genuinely helpful or for HCPs to recommend their use [44]. In the UK, this issue is being addressed by the Organisation for

the Review of Care and Health Applications (ORCHA). ORCHA reviews health and care apps, evaluating them against > 300 criteria, assessing for compliance with the relevant clinical, data and usability standards to ensure that any health or care app that meets ORCHA's quality threshold is safe and effective and easy to use. Validation of apps through organisations like ORCHA is showing the way and setting the standard in healthcare in the UK and increasingly in the EU. This is likely to accelerate the change in delivery of healthcare that is already underway—leading medical researcher, author and cardiologist Eric Topol to recently state: "I am prescribing a lot more apps than medicines these days" [45].

In January 2021 ORCHA published a report in collaboration with the British Dietetic Association, which reviewed weight management apps and provided recommendations for dietitians on how to use mHealth applications in their practice [46]. The report recommended ten apps, which met its quality threshold. They provided a diverse range of functions from information about diabetes, to calorie counting, to a 3-month weight loss intervention. Many of these are suitable for people with obesity, although a similar library of apps specifically helpful for obesity care and weight management would be hugely welcomed.

There is also a potential role of health and care apps in supporting bariatric surgery patients, based on the Elective Care Digital Health Toolkit recently launched by ORCHA to support the millions of patients currently on elective surgery waiting lists in the UK [47]. They select the best digital products to support patients during three stages: first, support for the patient to prevent deterioration of health whilst waiting for their operation; second, providing pre-operative support to improve the chances of successful outcomes from the surgery; finally post-operative support and monitoring. A digital health toolkit, specifically aimed at supporting patients undergoing bariatric surgery, could be developed along similar lines to support weight management and healthy behaviours and improve care both pre- and post-operation and maximise the likelihood of positive long-term outcomes.

Wearable Devices

Wearable fitness monitors enable users to track a range of health metrics, including physical activity, quality of sleep and heart rate. Fitbit and Apple Watch have electrocardiogram (ECG) apps which have been cleared by the US FDA to assess heart rhythm for atrial fibrillation, so these devices have the potential not just to monitor physical activity, but also help to prevent cardiovascular disease, a common comorbidity of obesity [48]. Within the next few years, smart wrist bands are expected to come to market which are able to accurately measure not only physical activity, heart rate and blood pressure, but also blood oxygen and glucose levels and a number of other bio-markers [49]. This should provide a significant advance in monitoring patients with a variety of health conditions, including obesity and associated comorbidities. The data can be transmitted directly to the patient's health record for interpretation by their healthcare professional.

An important consideration for the implementation of mHealth interventions for obesity care, particularly involving wearables and other smart devices, is the accessibility of technology to all patients, as obesity disproportionately affects those in lower socioeconomic status. If technology is only available to those who can afford it, existing inequities in healthcare will only be exacerbated. As with telehealth, it is therefore incumbent on health services to ensure access to devices and other technology and provide digital literacy support where necessary to ensure equitable access to mHealth technologies for weight management and obesity care.

Just-in-Time Adaptive Interventions

Just-in-time adaptive interventions (JITAIs) are an advanced form of mHealth. JITAIs deliver interventions using integrated mHealth sensors (wearable devices) and apps. They aim to provide the right type/amount of support, at the right time, by adapting to an individual's changing behaviour—they utilise technology that dynamically adjusts the intervention

approach based on an individual's changing behaviour in real time [50]. JITAIs have been shown to diminish sedentary behaviours and increase physical activity in individuals with obesity [51, 52], and a trial is underway to test a JITAI aimed at preventing lapses in healthy eating behaviour [53].

The principle benefit of JITAIs is that they recognise the immediate context that can impact the adoption and maintenance of health behaviours. mHealth sensors enable collection of information on the behavioural context, which can be used to trigger immediate behaviour change support. JITAIs offer an excellent opportunity for improving adherence to behaviour change, and future developments will hopefully see JITAIs emerge that are transdisciplinary, working across several behaviours. Incorporation of machine learning algorithms could advance JITAIs by analysing data and feeding back so that messages can become more personalised [54, 55].

Artificial Intelligence and Machine Learning

Artificial intelligence and machine learning (a simple form of AI) will play an important role in the future of digital health. One important aspect of this is their ability to analyse huge data sets and uncover patterns and insights that humans could not find on their own. Through analysis of data from electronic health records (EHRs) of patients with obesity, AI could provide greater understanding of the complexity of obesity, leading to prediction of responses to different treatments and therefore personalisation of interventions [56]. A systematic review of machine learning applications for the prevention and treatment of childhood obesity found that machine learning techniques have already been found to generate useful knowledge to predict childhood obesity [57]. The authors recommended that integration of machine learning algorithms into electronic tools is needed to develop smart and impactful digital health interventions for obesity.

An example of using AI/ machine learning in weight management is under development in the area of personalisation of diets. David Zeevi and colleagues in Israel developed a machine learning algorithm that accurately predicted personalised postprandial glycaemic responses to different meals. They achieved this by monitoring blood glucose responses to standardised meals in an 800-person cohort over a 7-day period, measuring responses to 46,898 meals in total. They integrated these data with further measurements of blood parameters, dietary habits, anthropometrics, physical activity and gut microbiota. A blinded randomised controlled dietary intervention based on this algorithm resulted in significantly lower postprandial responses and consistent alterations to gut microbiota configuration, suggesting that personalised diets may successfully modify elevated postprandial blood glucose and its metabolic consequences [58]. This work has been built on by Professor Tim Spector of King's College London in the PREDICT study [59]. They have gathered gut microbiome and other health and dietary data and used it to develop a test and an app which will give people the power and confidence to choose the right foods that will optimise their personal metabolism. This research, and subsequent test and app, offers the opportunity for truly personalised dietary interventions to support metabolic health and weight management.

AI for Behavioural Interventions

Artificial intelligence can also play a role in behavioural interventions as part of weight management programmes—the next step beyond JITAIs. An example of this is Tess, an AI behavioural coaching chatbot. Tess has been designed for teenagers, who are generally very comfortable using technology in their day-to-day life. Available 24/7, Tess delivers customised integrative support, psychoeducation and interventions through brief conversations via existing communication channels (i.e. SMS text messaging and Facebook Messenger). In an initial study Tess was successfully implemented to help support teens in a weight management programme by promoting treatment adherence, behaviour change and overall wellness.

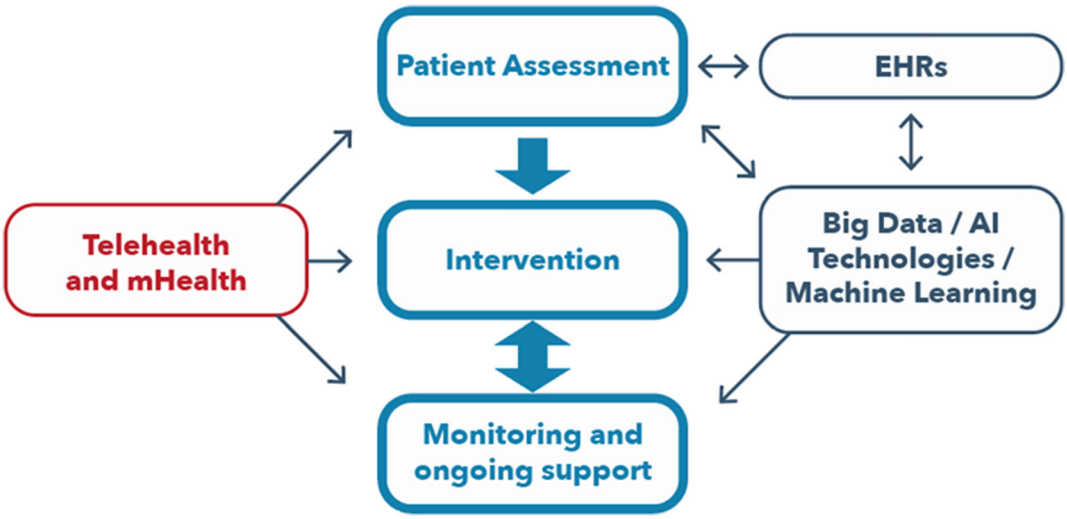

Fig. 1 Potential role of digital health in obesity care

Adolescent patients reported experiencing positive progress toward their goals 81% of the time [60]. As a partner to clinicians, Tess can continue the therapeutic interaction outside office hours while maintaining patient satisfaction. Due to a capacity for continuous learning, future iterations of Tess may have additional features to improve the user experience.

Another idea currently being explored is whether AI-powered cognitive assistants could be deployed in line with the 'nudge theory' to support people in making better decisions regarding their health. 'Nudge theory' holds that subtly encouraging people to change their behaviour through a series of gentle reminders is a far more effective means of motivation than telling them to change [61]. Health professionals don't have the capacity to deliver this kind of support, but a conversational AI can act as a behavioural coach, nudging patients to follow a healthier lifestyle at home. This could help keep the patient on-track between meetings with their health professional. Through regular conversation with the patient, the cognitive assistant can support those undergoing a weight management programme to educate them, keep them motivated and ensure they are adhering to the plan. With frequent, conversational interactions between patient and coach, the cognitive assistant is able to offer real-time feedback and personalise advice to help the person develop and maintain healthier routines [62]. People who are used to interacting with a smart speaker such as Apple Homepod or Amazon Echo would probably be quite comfortable with such a technology.

A recent review of the potential for AI to be used to regulate eating and dietary behaviours, exercise behaviours and weight loss identified three categories of AI applications with potential in meeting these aims:

- *Machine perception*: can be used for recognising food items, eating behaviours, physical activities and estimating energy balance.
- *Predictive analytics*: can predict weight loss, intervention adherence, dietary lapses and emotional eating.
- *Real-time analytics with personalised micro-interventions:* AI-assisted weight management interventions that instantaneously collect behavioural data, optimise prediction models for behavioural lapse events and enhance behavioural self-control through adaptive and personalised nudges/prompts. This is perhaps the ultimate goal for personalised digital behaviour change interventions, whereby AI is able to continually adapt the intervention to meet the changing needs of the individual in real-time to maximise their chances of success.

The authors of the review concluded that the use of AI for weight loss is still undeveloped and identified the lack of integration and synthesis of all three AI categories as a large gap in the evidence on how AI can assist in weight loss self-regulation. They proposed a framework for the potential use of AI to improve weight loss and suggested future studies could compare the effectiveness of AI-assisted self-regulation weight loss programmes and existing behaviour change programmes to assess the resource efficiency of AI-assisted interventions [63].

The Internet of Things (IoT)

The development of new smart devices, wearable technologies and the Internet of Things (IoT) is creating the infrastructure to support data collection and real-time monitoring of patients, which is a critical part of behavioural treatment for obesity.

The Internet of Things (IoT) describes physical objects (or groups objects) with sensors, processing ability, software and other technologies that connect and exchange data with other devices and systems over the internet or other communications networks [64]. In healthcare terms, the IoT, sometimes called the IoMT (Internet of Medical Things), is a network of smart devices that connect directly with each other to capture, share and monitor vital data automatically [65]. The development of the IoMT has great potential value for obesity care—by exploiting the wide range of wearables and smart devices already described, IoMT enables real-time monitoring of patients and real-time data analytics and the development of AI-assisted personalised weight management interventions. IoMT also enables the creation of self-contained digital ecosystems for specific conditions, such as that proposed here for obesity care, which will likely accelerate the uptake of digital health applications [66].

However, before this can become a reality, issues around cyber-security of IoT-linked medical devices need to be resolved, with recent research from the US finding that 75% of medical IoT devices had known security gaps [67]. Regrettably, medical devices in the UK do not come under the jurisdiction of the new Product Security and Telecommunications Infrastructure (PSTI) Bill, due out in late 2022, which covers security for other IoT-connected devices. So there is currently inadequate guidance and regulation for these devices, an issue which needs to be addressed by authorities around the globe to prevent vulnerability of new digital health solutions to cyber-attack [68].

CONCLUSION

Digital health technologies have potential to improve the quality, efficiency and cost-effectiveness of care for people living with obesity, both now and in the future. All stages of care can benefit, from patient assessment to treatment and ongoing monitoring and support (see Fig. 1).

Telehealth and mHealth are already widely used in delivering healthcare and self-monitoring of health parameters and behaviours. They offer emerging opportunities to reduce barriers to effective obesity care (faced by both patients and HCPs), improve access to care and ultimately improve long-term weight management and obesity-related health outcomes. Measures must be taken to ensure patients from the most deprived communities have equitable access to telehealth and mHealth services.

Machine learning and artificial intelligence are playing an increasingly important role in healthcare and provide a number of opportunities for obesity care. Analysis of large data sets from electronic health records can provide greater understanding of the complexity of obesity, leading to improved patient assessment and a precision approach to obesity treatment. Artificial intelligence can also be applied to mHealth technologies, connected via the IoMT, to provide real-time patient monitoring and truly personalised weight management interventions.

In the immediate future, the most significant digital advancement in obesity care is likely to be the increased use of telehealth support to allow increased access to care, increased frequency of consultations and longer-term support. Over time this will be increasingly

supported with mHealth apps and devices. Ultimately, interventions and ongoing support are likely to be delivered by proxy with an avatar or through a chatbot using AI technology.

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Compliance with Ethics Guidelines. This article is based on previously conducted studies and does not contain any new studies with human participants or animals performed by any of the authors.

Data Availability. Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

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