Introduction

The high incidence of childhood obesity has been well documented; with 29% of children aged 2-15 years in England [1], and a quarter of children living in Northern Ireland [2] classed as overweight or obese. Furthermore, approximately one-fifth of children in the UK are meeting the recommended guideline of at least 60 minutes per day of moderate-to-vigorous physical activity (MVPA) [3,4]. The associated risk of developing obesity-related co-morbidities earlier in life mean that schoolchildren are a key target population for the promotion of sustainable healthy behaviours [5].

Interventions to promote healthy behaviours in children have largely focused on the school-setting [6,7], with only 7% of randomised controlled trials (RCTs) targeted at the home-setting [6]. The influence of parents and other family members on health behaviours in children is well-established [8,9]. Research has highlighted the need for interventions that target children within the home environment [10] which to encourage positive behaviours before children progress into adolescent and develop more autonomy over their health choices and the influence of the family context wanes [10]. Family-based interventions typically involve the target child/children and at least one other family member, typically a parent [11]. Without the involvement of family members in interventions, long-term behaviour change is unlikely to be sustained in children [12]. A recent meta-analysis identified 19 family-based interventions targeting physical activity, with 66% of included studies reporting a positive effect on physical activity [12]. This is in contrast to lower levels of effect noted in reviews of school-based interventions [13,14]. Family-based interventions that target diet alongside physical activity appear to be more effective in reducing BMI z-score, when compared with diet or physical activity only interventions; however, the evidence is considered to be of low certainty [6]. Furthermore, interventions that target the family psychosocial environment, and put an emphasis on the child as the agent of change warrant further investigation [12].

Alongside family involvement, incorporating technology within the family setting has been identified as a potential means of enhancing the effectiveness of interventions targeting childhood obesity [15,16] and may also present further opportunity to increase the reach of interventions [16]. There has been a rapid increase in interventions adopting technology as it can provide a cost-effective means of providing information and feedback alongside existing interventions, or can function as a stand-alone intervention [17,18]. Children and adolescents have been described as 'digital natives', having been exposed to technology for most of their lives [19]. This coupled with high levels of smartphone ownership (78% of adults) and broadband connections (80% of homes) [20], highlights the potential of internet-based technologies for changing health behaviours.

Researchers and practitioners have utilised technology to both change how we deliver interventions (e.g. moving from print-based information to online websites) and how we incorporate

behaviour change techniques within interventions. To date, interventions utilising interactive electronic media [18] or web-based management programs [21] have demonstrated some potential for weight management; however, studies were generally of a lower quality, and largely conducted in the USA [18]. A recent systematic review identified 8 eHealth interventions (comprising internet-based interventions, voice prompts or telemedicine) whereby parents/guardians were the agents of change [16]. Included studies did not report a significant effect on BMI or BMI z-score, however, half of the interventions reviewed found significant improvements in physical activity or dietary related outcome measures [16].

There is a strong need for research studies to target the family-setting [22]. Innovative interventions are required [23], with the aim of improving both parent and children's behaviours. In addition, there is a need for interventions to include more detailed process evaluation with their methodology to further understand the reasons why certain interventions are, or are not, effective in this setting [6]. Intelligent personal assistants (e.g. Amazon Alexa) represent an efficient, low cost method of delivering individualised behavioural interventions, with the potential for scaling at the population level [24]. Unlike other technologies such as wearable devices (pedometers, FitBits etc) which have been a primary focus for research studies in recent years, little is known about the potential role that intelligent personal assistants can play in positively influencing health-related behaviours [25].

The present study (1) outlines the development of GetAMoveOn+ Intelligent Personal Assistant Project (IPAP), (2) compares the acceptability of intelligent personal assistants alongside an existing intervention or as a standalone intervention and (3) evaluates the potential of intelligent personal assistants for promoting and maintaining physical activity and other health-related behaviours in both parents and children.

Methods
Study Design

IPAP was a 12-week randomised controlled trial (RCT), conducted in two phases. Phase 1 was an RCT which evaluated the effect of a home-based intelligent personal assistant intervention on obesity-related behaviours (diet and physical activity) in families attending a community-based weight management project.

Phase 2 was an RCT which evaluated the effect of the home-based intelligent personal assistant in families not attending a weight management project. Randomisation for both phases of recruitment took place at the family level, with families (a parent and one or two children) randomly allocated to an intervention or control group. Randomisation was performed by a University staff member who

was independent of the research team. Sealed, opaque envelopes were used to randomly assign families to a study arm.

Participants

Families were eligible to participate when at least one child (aged 5-12 years) and one parent/adult responsible for their care consented to take part in the study. Given the nature of the intervention, access to Internet connection with their home (Wi-Fi) and ownership of one smart device within the home (e.g. a tablet or smartphone) or access to a computer/laptop to enable the family members to interact with the home-based intelligent personal assistant was required. The adult and child/children taking part in the study also had to live within the same household. No restrictions were placed on family type. No inclusion criteria were placed on parents or children in relation to any medical conditions. Participants were asked to notify the research team of any related issues that might impact participation on the intervention. No issues that limited/impacted participation or resulted in adverse events were reported.

Recruitment
Phase 1

All families (n=16) attending a community-based obesity prevention project; Safe Wellbeing Eating & Exercise Together as a family (SWEET) were invited to take part in the study. The SWEET project is a community-based obesity prevention and management programme aimed at children and families across a number of sites (community organisations, Healthy Living centres etc) in the Western Trust area of Northern Ireland. It aims to work with families in areas of high economic deprivation and targets lifestyle characteristics such as dietary habits, physical activity and mental well-being. Families are recruited to the SWEET project via social media sites, flyer distributions in schools and local paper advertisements. Prior to approaching families, permission was obtained from the Healthy Lifestyle Co-ordinator of the Healthy Living Centre where the project was being delivered. Members of the research team attended the first session of the project and provided a verbal overview of the research study. Written informed consent was obtained from all parents/guardians and written parental consent and child assent was obtained for each child. Phase 1 of the study was conducted from January – April 2019.

Phase 2

Phase 2 was subsequently undertaken to further assess the acceptability of intelligent personal assistants as a standalone intervention. Potentially eligible families (as per above) were invited to take

part in the study (not restricted to those attending the SWEET project) through a number of recruitment strategies. Local community group leaders were contacted and asked to provide permission for a member of the research team to approach families (parents) at relevant events e.g. parent/child groups, youth club, sports training sessions etc. Similar to Phase 1, prospective families were provided with a verbal overview of the study and provided with detailed written information on the study. Written informed consent was obtained from all parents/guardians and written parental consent and child assent was obtained for each child. Efforts were made by the research team to ensure families in Phase 1 and Phase 2 were recruited from similar community groups, to avoid any potential sampling bias. Phase 2 of the study was conducted from May – August 2019. Families were only able to participant in one phase, i.e. families who took part in Phase 1 were not eligible to take part in Phase 2.

Intervention selection

A smart speaker (Amazon Echo) and its linked intelligent personal assistant (Amazon Alexa) were chosen as the tool for intervention delivery within the present study. A market survey (n=2,274) highlighted 33% of respondents, based in the USA and UK, owned a smart speaker [26]. Within this, Amazon's devices were the most popular.

Intelligent personal assistants can perform a range of basic home assistant functions, including playing music, setting alarms, checking the weather and searching for information. Users can also personalise the devices by adding applications or 'Skills', which further the device's capabilities [25]. Research has shown that 'Health and Fitness' applications are readily available for devices, with health education and fitness training applications the most common types of 'Health and Fitness' applications [25]. The IPAP intervention involved utilising the existing features and skills developed for the Amazon Echo devices.

Intervention description and protocol

Following completion of baseline measurements, families recruited to both Phase 1 and Phase 2 of the study were randomly allocated to either intervention (receive an intelligent personal assistant), or control (continue as usual without the provision of additional technology within the home). The IPAP intervention aimed to promote positive health behaviours in the family setting, through utilisation of the functions of a smart speaker and its linked intelligent personal assistant. Each family in the intervention arm of the study received a smart speaker (Echo Dot, 3rd Generation, Amazon 2018 release) for use in the family home for the duration of the intervention (12 weeks).

The research team set up an individual user account for each family, creating a new email and password, not linked to the family's other email accounts (for security purposes). Each family was provided with their log in details also, meaning the research team and family members could both access the accounts during the intervention period. Each family was provided with a detailed information sheet on how to set up and use the device and were instructed to contact a member of the research team for support/troubleshooting throughout the intervention period.

The research team were able to remotely access the devices and set weekly tasks, prompts and reminders for family members. The prompts and reminders provided by the research team were developed in line with recommendations for the management of childhood obesity [27] and based around current public health recommendations in relation to physical activity [28] and dietary habits [29]. Examples of weekly prompts/reminders and potential ways the family could interact with the device are shown in Table 1. For Phase 1, the intervention content from the device was aligned to the topics covered at each week of the SWEET programme, ensuring the message were appropriate for the target population. Families received one specific reminder or prompt per day, which was repeated at a number of times throughout the day to maximize reach. Reminders/prompts were delivered in the morning (before work/school) and in the evening. Families were asked to advise the research team of the most convenient times to receive the prompts/reminders. Families were also encouraged to inform the research team if they were missing the prompts/reminders. In these instances, the timings were revised.

In addition, families were informed that the devices were to be used as a health promotion tool within the home setting, and were free to add their own reminders at times convenient to them, and had complete autonomy over what 'Skills' (applications) they wanted to enable on their devices. A specific 'Skill' was not developed for this intervention, rather families were signposted to search for 'Skills' under the topics of Health and Fitness, Lifestyle, Sport, Cooking and Recipes etc. Within this, families could choose skills most suitable to their children's age and interests. In addition to the pre-programmed messages controlled by the research team, families were instructed that they were free to use the devices for other general functions, not specific to the research project.

Families were informed during recruitment and throughout the intervention that the research team would also be able to view and manage their user accounts. Families were also made aware that all interactions with the device would be noted by the research team, including interactions that may not be linked to the goals of the intervention, for example, asking the intelligent system non-related questions.

Table 1: Examples of intervention components delivered by the intelligent personal system

Intervention Component	Type of interaction	Interaction content
Diet	**Skill**	Ask 'Vitality' [device-based skill] to give you a recipe –pick a simple meal and have a go cooking with Alexa.
	Task	Plan your shopping list for the week and add foods to your list using Alexa.
	Tip	"Fruit and vegetables that are fresh, frozen or tinned all count towards your 5-a-day"
	Reminder	"How much water have you had today?"
Physical Activity	**Skill**	Use Alexa to find some fun games that can help you be active.
	Task	"Kids, do 10 star jumps every morning"
	Tip	"You should aim to be active daily – try going for a 30-minute walk on most days this week."
	Reminder	"Have you been for a walk as a family this week?"

Outcome evaluation measures

Within the present pilot feasibility study, we aimed to evaluate the potential of intelligent personal assistants for promoting and maintaining physical activity and other health-related behaviours in both parents and children. Data collection was carried out at local community centres or at the University by trained researchers and all participant outcome measures were assessed at baseline and follow-up (12 weeks).

Physical activity

Physical activity was measured using an Actigraph GT3 accelerometer (Actigraph LLC, Florida). Participants (parent and child/children) were instructed to wear the device on the waist for 7 consecutive days, removing it only for bathing, water-based activities such as swimming and when asleep. During measurement periods, participants were asked to keep a family log of when they wore the accelerometer/ took it off etc. A sampling epoch of 15 seconds was used for data collection. Periods of ≥ 60 minutes of zero counts were classified as non-wear and were removed. Cut-points were used to estimate time spent in sedentary behaviour and light, moderate and vigorous intensity physical activity for adults [30] and children [31]. The primary outcome was total physical activity (light, moderate and vigorous physical activity combined). Secondary accelerometer outcomes included data provision, and proportion of participants meeting the recommended guidelines for physical activity [28]. Participants who provided at least three weekdays of at least 480 minutes of data between 05:00 and 23.59 were included in the analysis. Families were given an incentive at each time point for returning the devices (£20 One4All voucher).

Health outcomes

Height (nearest 0.1cm) and weight (nearest 0.1kg) were measured according to standardised protocols. Body mass index was calculated and converted to BMI z-scores using the World Health Organization (WHO) AnthroPlus software (version 1.0.4).

Family Eating and Activity Habits

Behaviours related to eating and activity habits were assessed using the Revised Family Eating and Activity Habits Questionnaire (FEAHQ-R). The FEAHQ-R is a 32 item self-report instrument designed to assess changes in eating and activity habits of family members, as well as obesogenic factors in the overall home environment (stimulus and behaviour patterns) related to energy balance [32]. The questionnaire was completed by one parent on behalf of themselves, their spouse and their child. Summary scores were calculated for physical activity, eating style, stimulus exposure (e.g. unhealthy snacks at home), eating related to hunger. A reduction in scores signifies improvements across all domains.

Process evaluation

Device interactions and usage: The research team were able to access each family's account via their log on details and view each interaction with the device across the intervention period. An interaction was defined as any engagement with the device made by a parent or child, in addition to the reminders and information provided by the device from the research team. A copy of all interactions was downloaded from the device website, and anonymously stored. The research team recorded the number of interactions and the type of interaction. Interactions were primarily coded as 'Relevant' (related to physical activity/diet/wellbeing) or 'Non-Relevant' (i.e. not related to the intended purpose of the intervention), with relevant interactions further coded based on their theme. For example, "How many portions of fruit and vegetables per day should I eat" was recorded as a relevant interaction, and sub-coded under 'Healthy Healthy-eating question'. 'Waking up' the device, controlling volume and prompts such as 'Next song' were not recorded as interactions for the purposes of the present study. In instances where the device was not able to provide a transcript of the voice command received, the device registered this interaction as: 'Text not found. Click here to listen to the recording'. The research team did not listen to the voice recordings or include these within the interaction analysis. It was not possible for the research team to distinguish whether a parent or child was interacting with the device.

Intervention acceptability: A record of any technical issues in relation to the smart speaker was held by the research team. All parents in the intervention arm of Phase 1 and Phase 2 were invited to take

part in focus group discussions. These discussions focused on the acceptability of the intelligent personal assistants, intervention fidelity, any challenges that arose during the intervention, and suggestions for future improvements. Due to practical issues (timing and location), it was not possible to facilitate focus groups with all parents, so these were replaced with semi-structured interviews. One focus group (n=4 parents) and three semi-structured interviews (n=3 parents) were conducted with participating parents in the intervention arm of the study. All discussions were audio-recorded. The mean duration of the recordings was 26 ± 20 minutes.

Ethical considerations

Participants were provided with detailed instructions on use of the device, and the functionality of the device i.e. what the device is capable of doing and picking up. The mute/temporality disable functions of the device were also highlighted to families. These instructions were developed using the manufacturer's own guidance. As these devices were present within the home, and accessible to both parents and children, a protocol was developed to consider the potential issue of disclosure and unintended collection of data. No such issues presented during the intervention period. The search history of the device was kept confidential, and the device was not used for any other purpose during the intervention, for example, recording information/conversations within the home. This pilot feasibility study was approved by Ulster University Research Ethics Committee and was registered retrospectively (ISRCTN16792534).

Data Analysis

Quantitative: Frequencies, percentages, means and standard deviations were used to describe data related to recruitment, retention, outcome measures, intervention acceptability, device interactions and usage. Data analysis was conducted using SPSS for Windows (Version 25, SPSS Inc, Chicago, IL, USA).

Qualitative: Focus groups and semi-structured interviews were transcribed verbatim and analysed thematically, following a deductive approach [33]. Following familiarisation with the data, each transcript was reviewed for meaningful quotes and systematically coded by a member of the research team. Potentially relevant codes were grouped together to develop themes, which were reviewed to ensure representativeness. These themes were then reviewed by a member of the research team to ensure the themes were representative of the coded excerpts. Coding and reviewing of themes were repeated independently by a second member of the research team.

Results

	Phase 1		Phase 2	
	Adults (n=11)	Children (n=16)	Adults (n=15)	Children (n=18)
Sex (% female)	90.9	56.3	73.3	44.4
Age, year (± SD)	40.5 ± 5.4	9.1 ± 2.0	38.9 ± 5.2	7.9 ± 2.0
Height, cm (± SD)	166.0 ± 6.2	141.1 ± 14.5	166.9 ± 8.5	130.0 ± 12.8
Weight, kg (± SD)	97.0 ± 22.8	49.5 ± 15.4	81.4 ± 15.8	28.3 ± 7.7
Body Mass Index, kg/m²	35.0 ± 6.4	N/A	29.1 ± 4.9	N/A
Body Mass Index Z-score	N/A	2.61 ± 1.23	N/A	0.02 ± 1.17

Recruitment and retention

Phase 1

16 families attending the SWEET project were invited to take in the IPAP study (Figure 1). Of the 16 families approached, 1 family was excluded for not meeting the inclusion criteria and 4 families failed to respond to the initial invitation. Of the 6 families allocated to the intervention, 2 families did not set up the device. Of those allocated to the control arm, 1 family was absent for follow up measurements, while a further 2 families discontinued with the SWEET project, and subsequently the present study also. Participant characteristics are described in Table 2. All adult participants were categorised as overweight/obese at baseline.

Table 2: Individual participant characteristics at baseline

Phase 2

20 families from local community groups were approached to take part, of which 16 were assessed for eligibility (Figure 2). 15 families were enrolled onto the IPAP study, with all families retained at follow up. Participant characteristics are described in Table 2. 80% of adult participants were categorised as overweight/obese at baseline.

Outcome evaluation measures

Physical activity

In Phase 1, 90.9% of adults and 69.8% of children met the minimum inclusion criteria for accelerometer wear time. At baseline, mean valid wear time was 720 ± 90.3 and 657.2 ± 47.8 minutes per day for adults and children, respectively. At follow up, the proportion of participants meeting the minimum inclusion wear time dropped to 54.5% of adults and 18.8% of children. In Phase 2, 87.7% of adults and 88.9% of children met the minimum inclusion criteria for accelerometer wear time. At baseline, mean valid wear time was 782.1 ± 63.2 and 695.4 ± 36.3 minutes per day for adults and children, respectively. At follow up, the proportion of participants meetings the minimum inclusion wear time dropped to 86.7% of adults and 72.2% of children, indicating greater compliance to the accelerometer outcome measure in Phase 2 of the IPAP study.

Of those who fulfilled the minimum wear time criteria, 70% of adults, and 36.4% of children achieved the recommended physical activity guidelines at baseline for Phase 1, compared with 76.9% of adults and 37.5% of children in Phase 2 of the study. Due to the small sample size, statistical testing was not undertaken to assess changes in physical activity pre- and post-intervention (Table 3). Adherence to the accelerometer protocol may have been affected by the timing of the intervention and follow up measurements, coinciding with school holidays.

Table 3: Change in accelerometer measured physical activity across the IPAP study (adults)

	Intervention Mean ± SD	Control Mean ± SD
Phase 1		
Baseline (n=10)		
Daily physical activity (mins/day)	268.5 ± 35.3	234.2 ± 67.4
Sedentary behaviour (mins/day)	440.5 ± 115.5	492.8 ± 52.5
Follow up (n=6)		
Daily Physical activity (mins/day)	293.7 ± 57.8	201.1 ± 9.5
Sedentary behaviour (mins/day)	587.6 ± 132.8	531.4 ± 26.9
Phase 2		
Baseline (n=14)		
Daily physical activity (mins/day)	260.7 ± 35.6	241.8 ± 47.7
Sedentary behaviour (mins/day)	562.3 ± 10.1	492.7 ± 56.6
Follow up (n=12)		
Daily Physical activity (mins/day)	218.9 ± 40.7	244.8 ± 33.1
Sedentary behaviour (mins/day)	513.9 ± 65.1	498.3 ± 21.4

Values are mean ± SD

Family Eating and Activity Habits

Questionnaire data was provided by 84.6% of participants at all timepoints. In Phase 1, positive improvements in scores for eating style were observed for adults (-1.75 ± 2.06) and children (-0.50 ±

2.81) in the intervention group with increases observed in the control group. In Phase 2, there was a slight improvement in both the activity level score and stimulus exposure and control for children in the intervention group, with all other summary scores increasing across the intervention period (Table 4).

Table 4: Change in scores for Family Eating and Activity Habits Questionnaire for adults and children in Phase 2

	Adults		Children	
	Intervention N = 6	Control N = 5	Intervention N = 7	Control N = 4
Activity level	0.75 ± 2.72	1.70 ± 2.11	-1.07 ± 8.23	-0.25 ± 6.65
Eating style	1.80 ± 8.56	5.33 ± 1.15	3.33 ± 6.65	-1.00 ± 3.00
Eating related to internal cues	0.83 ± 1.33	0.00 ± 2.00	1.14 ± 1.46	-0.13 ± 1.55
Stimulus exposure and control	1.80 ± 4.09	1.25 ± 4.99	-0.25 ± 6.65	0.00 ± 4.63

Values are mean difference ± SD

Process evaluation

Device interactions and usage

Across Phase 1 of the intervention, families who received a smart speaker on average interacted with the intelligent personal assistant (Alexa) 65 times. 'Waking up' the device, controlling volume and prompts such as 'Next song' were not recorded as interactions for the purposes of the present study. 'Other' (including general knowledge questions and jokes) and 'Music' were the most frequently observed interactions across the intervention period (Figure 3). 42% of all device interactions were coded as relevant in Phase 1 (i.e. related to diet/physical activity/wellbeing). Reminders/prompts involved the family setting their own reminders. Examples of 'Skills (diet)' and 'Skills (physical activity)' used by families across the intervention period included fitness skills, recipe skills and active game skills. During Phase 1, the prompts/reminders provided by the research team aligned with the topics and tasks the families were covering in the SWEET project.

In Phase 2, families were not attending the SWEET project, but the intervention content largely reflected the prompts/reminders provided to families in Phase 1. Device interactions across Phase 2 of the intervention were much higher, with families interacting with the device 312 times across the intervention period (equivalent to 31.3 interactions per week). Only 11% of interactions were coded as relevant (related to diet/physical activity/wellbeing). Of the interactions that were coded as relevant (Figure 4), the most frequent interactions were when families asked questions about

nutrition (healthy eating) or used 'Skills' related to healthy eating, for example, recipes or healthy eating tips.

Intervention acceptability

7 parents took part in focus groups/ semi-structured interviews to discuss their experiences of the IPAP project. At the offset of these discussions, parents acknowledged the prominent role of technology in their family's everyday lives, and the need to utilise it in a positive way:

> "Technology is there, and it can be used for good and evil. And it's not going to go away. The way they are growing up, they can't avoid it really so might as well try and use it for good." (Family 4, male),

and:

> "…they are probably more motivated by it [technology], so it probably is the future for the younger generation…" (Family 6, female).

Parents commented that the intelligent personal system motivated the child to engage with the intervention:

> "It actually motivated her quite a bit, because she was saying 'mummy, we need to go for a family walk now… or I need to eat my fruit or…" (Family 6, female).

Families found the intervention content acceptable and discussed how the prompts/reminders encouraged them to change their behaviours, in a fun way (Table 5). Families also highlighted how they utilised other features, such as the skills for recipes or home workouts (Table 5).

Families highlighted several ways to increase engagement with the intervention, including further suggestions on how to use the device within the home, and more personalisation of the prompts/reminders. The timing of prompts/reminders was a key component of the intervention delivery, and families noted practical issues with this, in addition to the importance of ensuring families were at home when the device was interacting with them (Table 5). Parents suggested incorporating other technologies alongside the intelligent personal system to facilitate this:

> "If it was connected to your phone, like a phone reminder as well, because Alexa's in the house" (Parent 2, female).

In addition, families felt the device needed to be linked to some type of feedback, to increase accountability and provide the families with opportunities to log their healthy eating or physical activity (Table 5).

Parents felt the intelligent personal assistants had an additive role to play in encouraging children to be healthier and could work alongside other types of intervention:

> *"I still think you need the traditional ways of activity rather than reliance on a device."* (Family 6, female),

and:

> *"…if there was an intervention or like, if there were a, a class or some sort of, erm, programme that was with, sent home with families and Alexa reminded you to do it…".* (Family 6, female).

Table 5: Supporting quotes from family focus groups and semi-structured interviews

Findings related to intervention delivery	
Sub-heading	*Supporting quotes*
a) **Device set up**	*"It was easy to set up and easy to use. Quite interesting but, and the prompts were very good."* (Family 1, Female)
b) **Prompts/reminders from the research team**	*"We got a prompt, quick do 10 sit ups, and I'm like come on children, everyone on the floor, let's do it! It was some craic [fun] like, and everybody just downed the phones and going to do that challenge. They loved it."* (Family 3, Female) *"The whole jist of it was brilliant, like the wee prompts it tells you… try this or try that, you know it's just planting that wee seed in your head and when that wee seed's planted, obviously you are gonna try aren't you, so I think it is a great thing."* (Family 2, Female)
c) **Utilising other device features**	*"…the easy access to the workouts so that you could just do it at a time whenever it suited you."* (Family 6, female) *"There were a couple of occasions where we asked Alexa for a healthy recipe to make something so we made a chilli one day and we asked Alexa for a recipe 'cos we were prompted by the device about, you know, healthy, eating healthily and stuff…"* (Family 5, male) *"[Child name] was new-fangled with it, she was more into the music in it, bopping about but it got her active too, she was asking me how to do this, and will you do this 'Flossing' … it was good from that point of view you know"* (Family 2, Female) *"Even her homeworks, she was going out and asking, she was asking me how to spell this, I said ask Alexa, just to get her doing things for herself."* (Family 3, Male)
d) **Overall device usage**	*"We probably could have utilised it much more but it's just the pure fact if we had more time. Erm, and the fact that we were away from it all day long and then we came in, in the evening, it's usually kind of a race, get the dinner made and…"* (Family 6, Female) *"…but after, like, a week or so they kind of almost forgot it was there and maybe that was our fault, we didn't encourage them to use it as much, erm, but the prompts I think were a good idea."* (Family 5, male)
Findings related to intervention optimisation	
Sub-heading	*Supporting quotes*
a) **Timing of prompts/reminders**	*"I think there was a couple of technical glitches where the timing wasn't right because we didn't seem to get the prompts and we used Alexa a lot like, we do ask a lot of questions and stuff but, erm, it didn't seem to prompt us; maybe we were out at the time."* (Family 4, male) *"You know, if we weren't at home…, I don't know how many prompts there were."* (Family 7, female)

b)	Lack of feedback provided	*"…but what it would say to me, "Have you had your five a day?" Do I shout back, "Yes," or, "Alexa, yeah," I don't know what way to answer…"* (Family 7, Female) *"If you had to log what you did, you know, because it's fair enough, erm, you could say, "Right, go for a family walk," but you know, then they come back and say, "Well how many kilometres did you do?" or whatever... to close the loop"* (Family 6, female)
c)	Concerns	*"I just worry about that whole side of technology, erm, never mind Alexa but all social media, erm, in terms of how, how that can be utilised against them and I suppose that's a worrying thing for me as a parent…"* (Family 6, female) *"I think if you find the right balance where, you know, I don't like the idea of my kids being constantly engaged to technology but I can see the benefit of, of that via a prompt or something like that but, you know, I wouldn't want them to be constantly going to Alexa…"* (Family 3, male)
d)	Increasing device usage	*"You know, I think they would maybe be set challenges to do because I think if they've, just can get an app and do so much, I'm not sure that they'll benefit from it."* (Family 6, female) *"I think if it was maybe a wee bit more personalised… I don't actually know what I was supposed to be doing with Alexa, you know… and maybe it was in the documentation somewhere, maybe there was a letter written somewhere that I didn't see, that I didn't read."* (Family 7, female)

In terms of concerns with having a smart speaker within the home, most parents commented that they were cautious of both increasing engagement with technology, and the potential issues with social media and young people (Table 5). These concerns in relation to internet access/social media were more prominent from parents than issues specific to the intelligent personal assistants themselves:

> *"…he's downloading games and I don't know what they are - I would be quite worried; not so much that it's listening, I wouldn't worry about Alexa listening, it's not gonna hear anything in my house."* (Parent 7, female).

Practical considerations

The majority of families were able to set up their user accounts, and link these to the smart speaker device. Two families did not set up their devices in Phase 1 of the study. Of these families, one parent noted they could not set up the device as they were sharing the house with another family, who did not want the device used, and the other family failed to respond to follow up instructions from the research team, meaning they did not receive the intervention content. All families in Phase 2 successfully set up and used the device.

The smart speakers had to be 'online' to allow the research team to set up reminders/prompts and refresh information on the family's interactions with the device. Two families in Phase 2 had their devices set to 'Offline' for extended periods of time, limiting the volume of interaction managed by the research team. A further family in Phase 2 registered the device with their own personal Amazon

account for 2 weeks during the intervention period, therefore the research team were unable to set prompts/reminders or access information on the family's interactions with the device over this time period. A protocol was also put in place to cover the potential issue of disclosure of information and unintended collection of data; however, no scenarios arose within the present study.

Discussion

To our knowledge, this is the first study outlining the development and usage of intelligent personal assistants to promote positive health-related behaviours within the home setting. Given the constraints that exist within current family-based interventions, including time and travel restraints [10], moving towards novel interventions that incorporate online learning may help improve engagement and attrition [10]. Within the present pilot feasibility study, we assessed the acceptability and feasibility of using intelligent personal assistants alongside more traditional intervention approaches, or as a standalone intervention tool. This feasibility study demonstrated that using intelligent personal assistants to deliver health-related messages and information within the home was feasible, with high levels of engagement from participating families. This work has also highlighted methodological considerations and opportunities for intervention improvement moving forward.

To date, there is a paucity of research on both the development of interventions utilising this technology, and the potential effectiveness of such interventions. An ongoing study is examining the role a voice coach intervention (Amazon Alexa/Echo), has on increasing levels of physical activity amongst overweight and obese cancer survivors [24]. In addition, Public Health England have utilised intelligent personal assistants (Amazon Echo) to encourage parents to adopt healthy behaviours around breastfeeding [34], by providing parents with general information and tailored advice based on the age of their child. The present study has highlighted for the first time, that families found this type of intervention approach acceptable and feasible within the home setting. The majority of families assigned to the intervention were able to set up and initialise their devices and engage with the intelligent personal assistant across the intervention period. Focus groups and interviews with parents highlighted that the prompts/reminders were particularly useful and commented that the intervention encouraged the family to be healthier in a fun way.

Recent research has highlighted the plethora of 'Heath and Fitness' related applications available for smart speakers [25], with health education, fitness and training, and nutrition the most frequently occurring of these applications. For the purposes of the IPAP intervention, prompts/reminders provided by the research team were based upon the devices existing functionality, and families were instructed to utilise the features already developed for these smart speakers. High levels of interaction

were observed across the intervention period, with a higher volume of interactions in Phase 2. Setting reminders/prompts, asking questions about nutrition and using physical activity and nutrition applications (Skills) were the most common relevant interactions across the intervention period.

The mean frequency of device interactions across Phase 2 was much greater (312 vs 65), but a higher proportion of interactions were coded as "relevant" in Phase 1 (42% vs 11%). This provides important insights into how families utilised the devices and suggests that linking the devices to an ongoing intervention, as with Phase 1, may be more directive in terms of prompting families to use the device for health-related interactions. The issue of families not adequately implementing intervention components has been highlighted in similar feasibility work, evaluating the use of a web-based intervention to encourage families to increase their physical activity [23]. Within the present study, families were provided with written instructions and reminders on how to interact and engage with the intelligent personal assistants. Parents highlighted several ways to improve engagement with the intervention, including incorporating challenges, providing feedback and clearer guidance from the intervention facilitators on how to use the device within the home. Within this feasibility study, the intervention facilitators were members of the research team. Given the important role of facilitators in terms of intervention outcomes [35], providing families with more guidance and training before the intervention, and ongoing support during, may improve family's utilisation of the device [23].
Given the small sample size within the present study, it was not possible to statistically compare the effectiveness of these two intervention approaches. As the families in Phase 1 were already attending the SWEET project, the results from Phase 1 and Phase 2 could not be combined. A recent systematic review highlighted that most family-based eHealth interventions combined technology with other types of delivery, for example, face to face counselling, nutrition lesson etc., and from the present literature, it is difficult to ascertain the exact effect of the eHealth component versus other approaches [16].

The development and feasibility testing of the intervention identified a number of important methodological considerations. Firstly, the research team were not able to control the content, or indeed validity, of the responses families received when they asked for information on healthy eating or physical activity. At present, there is limited insight on whether these applications are developed based on evidence-based guidelines or available materials [25]; therefore, assessing the accuracy of educational information provided by these devices would be an important methodological consideration moving forward. Indeed, a previous study examining the provision of medical advice from these devices highlights the importance of cautioning users not to use such technologies in place

of medical advice without consulting with their health care provider first [36]. Secondly, families noted that the intervention in its current format did not provide any opportunities for feedback, or accountability, with limited options for families to log their healthy eating or physical activity. Moving forward, studies should explore the potential of linking these intelligent personal assistants with other technologies, to monitor behaviours, set goals and provide feedback [37,38], which may help improve the effectiveness of technology-based interventions [39].

The implementation of the intervention was dependent on a few factors. An important practical consideration was the capacity of the research team to access the family's device remotely. If the device was switched off, or the family had Wi-Fi connection issues, the delivery of the intervention was affected as the research team were unable to set new reminders and prompts during these periods. During the focus group/interview discussions, parents highlighted how the timing of the prompts/reminders may have impacted upon their adherence to the intervention. Although attempts were made to tailor the intervention to suit individual family's schedules, future studies utilising similar intervention components should seek to provide families with further guidance and ownership in relation to managing the devices themselves.

Strengths and limitations

The IPAP study adopted a cross-sectoral, interdisciplinary approach to explore the role of intelligent personal assistants within the home environment for promoting and maintaining physical activity and other health-related behaviours in families. The intervention development and evaluation used novel methods to capture intervention engagement, addressing key recommendations for research in this field to adopt appropriate methodologies that enable interventions to be effectively evaluated [17]. The present study developed the intervention content and tested its feasibility in line with best practice for intervention development [40]. Due to the small sample size, no statistical analysis was undertaken at this stage to evaluate the effectiveness of the intervention. Accelerometer compliance was low during Phase 1 of the study, despite the use of incentives to encourage adherence. In addition, device usage was much lower across Phase 1. Given that these families were already taking part in the SWEET project at the time, they may have felt overburdened with data collection.

Conclusion

In conclusion, this study demonstrates the feasibility and acceptability of a family-based intervention using intelligent personal assistants. This novel intervention has highlighted important methodological considerations and provides important suggestions to further optimise the potential of intelligent

personal assistants to promote positive health-related behaviours with the home setting. This work will inform future pilot and fully powered studies, to build upon this feasibility work and test whether such interventions are effective at changing health-related behaviours, including physical activity and healthy eating.

Conflicts of interest

None to declare

Abbreviations

BMI, Body Mass Index; RCT, Randomised Controlled Trial; MVPA, Moderate-to-Vigorous Physical Activity

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Figure 1: CONSORT 2010 Flow Diagram for Phase 1 participants

Enrollment

Assessed for eligibility (n=16 families)

Excluded (n=5)
- ☐ Not meeting inclusion criteria (n=1)
- ☐ Non-responsive after initial enquiry (n=4)

Randomized (n=11)

Allocation

Allocated to intervention (n=6)
- ☐ Received allocated intervention (n=4)
- ☐ Did not receive allocated intervention (Didn't set up device) (n=2)

Allocated to control (n=5)
- ☐ Received allocated intervention (n=5)

Follow-Up

Lost to follow-up (Absent) (n=0)

Lost to follow-up (Absent) (n=1)
Discontinued intervention (Dropped out of SWEET project) (n=2)

Analysis

Analysed (n=6)
- ☐ Excluded from analysis (give reasons) (n=0)

Analysed (n=2)
- ☐ Excluded from analysis (give reasons) (n=0)

Figure 2: CONSORT 2010 Flow Diagram for Phase 2 participants

Enrollment

Assessed for eligibility (n=16 families)

Excluded (n=1)
- ☐ Non-responsive after initial enquiry (n=1)

Randomized (n=15)

Allocation

Allocated to intervention (n=8)
- ☐ Received allocated intervention (n=8)
- ☐ Did not receive allocated intervention (give reasons) (n=0)

Allocated to control (n=7)
- ☐ Received allocated intervention (n=7)
- ☐ Did not receive allocated intervention (give reasons) (n=0)

Follow-Up

Lost to follow-up (give reasons) (n=0)
Discontinued intervention (give reasons) (n=0)

Lost to follow-up (give reasons) (n=0)
Discontinued intervention (give reasons) (n=0)

Analysis

Analysed (n=8)
- ☐ Excluded from analysis (give reasons) (n=0)

Analysed (n=7)
- ☐ Excluded from analysis (give reasons) (n=0)
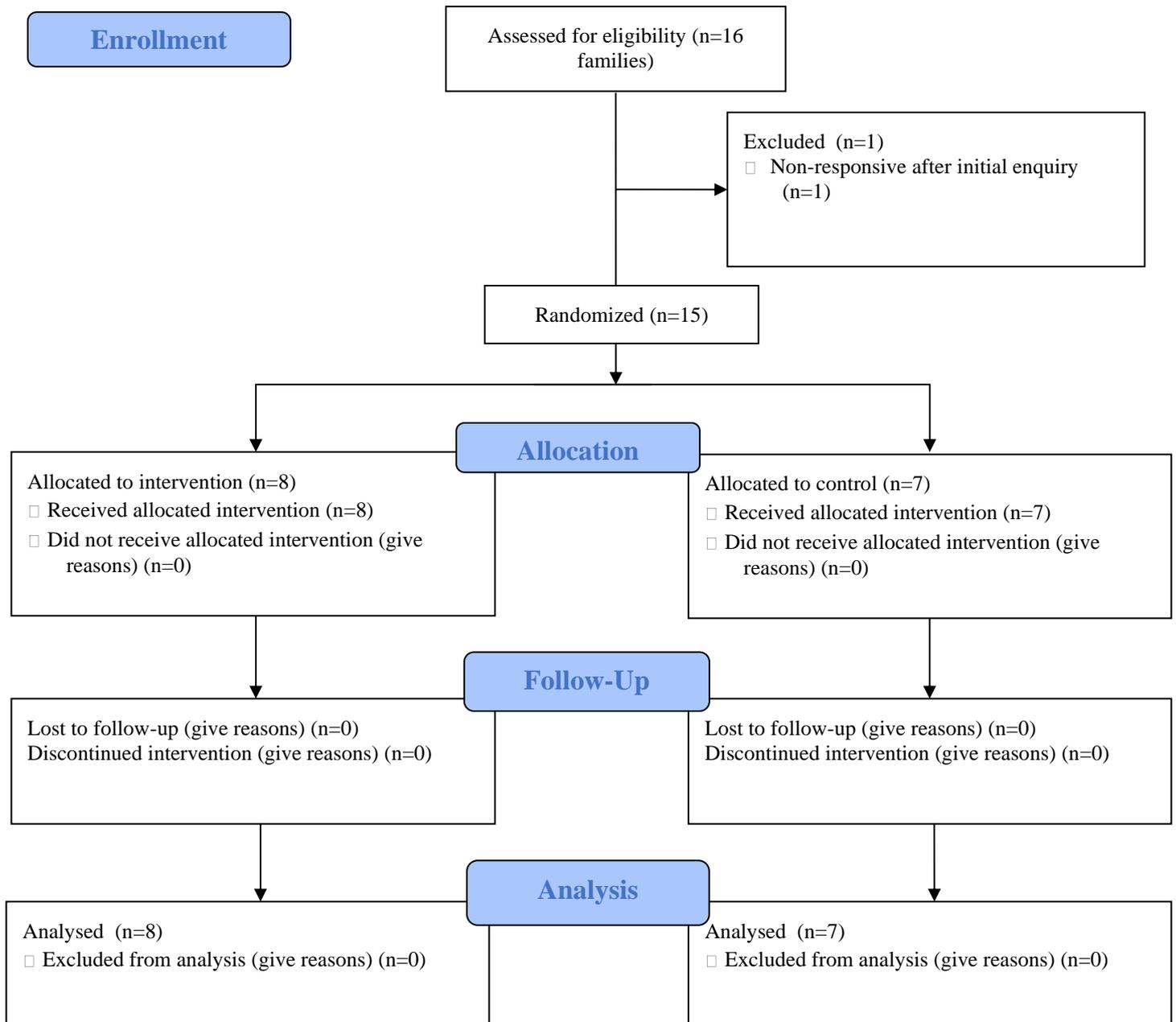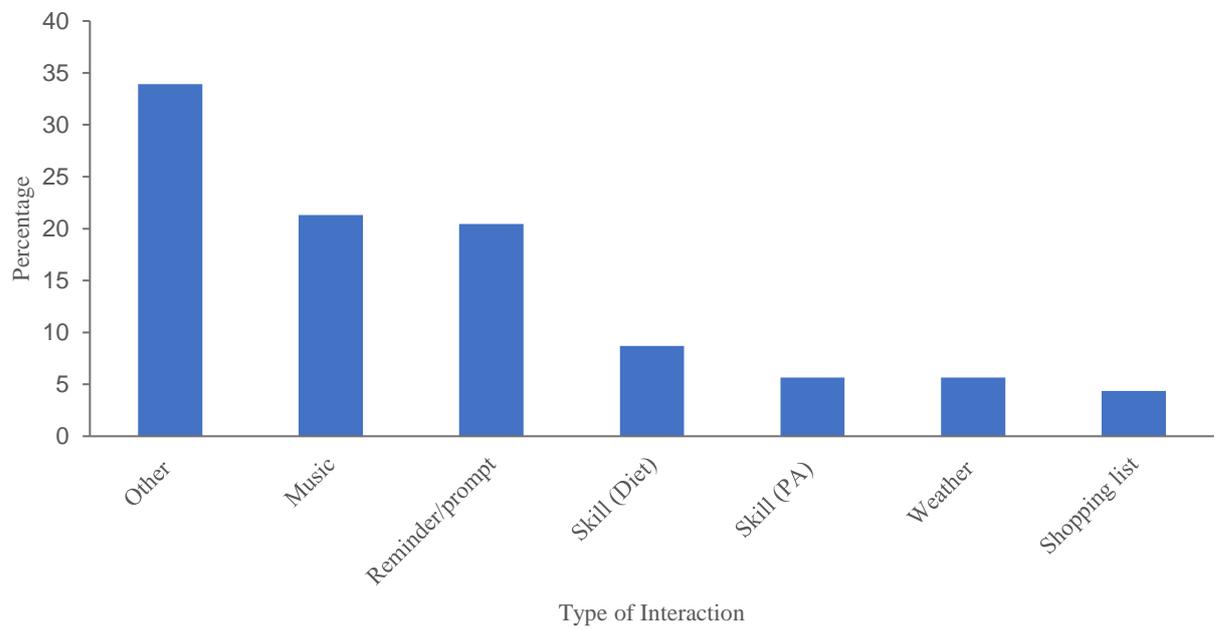
Figure 3: Device interactions across the intervention period (including 'Relevant' and 'Non-Relevant' (Phase 1)

Other – for example - general knowledge questions and jokes

Figure 4: 'Relevant' interactions across the intervention period (Phase 2)