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editorial

Mobile health interventions to support long-term health conditions.

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Editor
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Mobile health (mHealth) tools have become increasingly popular in delivering health behaviour change interventions, merely due to their potential to reach large numbers of people in diverse contexts. Mobile health interventions refer to the delivery of health messages via mobile phones, patients' monitoring devices, personal digital assistants, tablets, and/or other wireless devices (WHO, 2011; Yardley et al., 2016). Mobile health interventions can utilise pre-existing functionalities of these devices (e.g. voice, text, global positioning systems, bluetooth, radio-frequency identification etc.) to facilitate interactive advice and support. Such interventions could reduce the burden on traditional (mostly face-to-face) healthcare provision, especially when targeting people with single or multiple long-term health conditions.

Long-term health conditions affect millions of people and are leading cause of morbidity and mortality worldwide. For example, 422 million of people have been recorded with diabetes (WHO, 2016), and the numbers accelerate when counting for cardiovascular diseases or multi-morbidities (WHO, 2011; Di Angelantonio et al. 2015). However, the rapidly growing usage of mHealth to provide lifestyle advice to people with long-term conditions has evoked some scepticism from health researchers, primarly due to the lack of rigorous evidence on whether and how they can support health behaviour change.

In this Special Issue authors tap onto current knowledge to reveal the significant insight that mHealth interventions can provide to our understanding of health behaviour change. Authors also raise awareness on the challenges and facilitators on the development of such interventions and provide useful tips and recommendations for future mHealth interventions. Drawing on evidence synthesis and theory, authors stress the need of rigorous interventions to generate understanding of health behaviour change.

Keegan Knittle et al (2016) article reflects upon group discussions conducted during the Synergy Experts Meeting 2015 "MHealth for behaviour change: opportunities, challenges and future directions", convened by Lucy Yardley, Susan Michie and Robert West. The authors provide an overview the different modes to deliver mHealth interventions, users' experiences when engaging with mHealth interventions and the available tools to create and test such interventions. Authors also highlight the challenges, as well as the potential of mHealth interventions to produce novel and big data to inform the theoretical basis of behaviour change. Keegan and colleagues conclude with useful tips on how to promote collaboration with industry and recommend actions that could enable the EHPS to remain on the top of mHealth behaviour change research.

Katerina Kassavou and Stephen Sutton (2016) article describes the development and pre-test of a novel method to deliver behaviour change interventions: the Interactive Voice Response (IVR), the first IVR intervention to support medication adherence within the UK. For intervention development, authors discuss meta-analytic evidence on the efficacy of the IVR to produce

changes in four different health behaviours, and present results on coding interventions in term of theoretical basis and behaviour change techniques. For intervention pre-testing, authors present qualitative evidence on the acceptability of the IVR to support medication adherence to patients with Hypertension and/or Diabetes type 2. Kassavou and Sutton proved the capacity of the IVR to facilitate very brief behaviour change messages and conclude with recommendations on future IVR interventions.

Sumira Riaz (2016) article discusses the process of developing a 12-weeks text message intervention for patients with Inflammatory Bowel Disease. The author describes the different parameters to consider when developing a text message intervention and evaluate the acceptability of personalised messages. Riaz also reports on the theory used to inform the development of the intervention content, presents examples of how she mapped the messages onto the baseline measures, and concludes with useful tips to consider when developing such interventions.

Kristina Curtis (2016) article describes the process of developing two mHealth apps: the Health Heroes aiming to reduce children's eating portion sizes targeting parents; and MyMate aiming to support medication adherence targeting children with Sickle Cell Disease. Curtis describes the usage of 'The Behaviour Change Wheel' to map theoretical conditions to direct intervention components, the interaction design model to incorporate users' input, the collaboration with the development company to integrate design features and describes some methods to evaluate intervention development process. The article concludes highlighting the need for evidence-based apps.

Hynes et al (2016) article describes a dynamic, collaborative method of developing mHealth interventions. This novel approach applies design strategies from the technology world to healthcare innovations. In doing so, the authors recognized a need for healthcare professionals to learn from, and integrated pre-existing expertise of other disciplines, as well as stakeholders. Further, this approach offers an engaging method of developing prototype evidence-based interventions in a timely manner, before beginning a pilot randomised feasibility study.

Müller (2016) article calls for a culture-based approach to inform the development of behavioural digital interventions. Currently, much of evidence base for mHealth literature is based on research conducted in developed countries, limiting the global generalizability of findings. The cultural context is likely to influence factors such as the (health) behaviour, the interaction with mobile technology, and how user interfaces and intervention content is perceived.

Conclusion

The field of mHealth is rapidly emerging and has the potential to supplement traditional models of healthcare provision. This Special Issue has illuminated ongoing work and remaining questions about the future of mHealth to deliver advice and support. We thank all authors for their valuable contribution to this Issue and we truly hope that it will be a useful piece of information for all those interested in mHealth and long-term health conditions.

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synergy article

mHealth: past success, future challenges, and the role of the EHPS.

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Mobile technologies have great potential to extend the reach and effectiveness of health behaviour change interventions, and while a number of important developments have been realised, mHealth research remains in its infancy. As the EHPS is already quite active in mHealth research, it is well-placed to lead from the front on future innovations in the area. At the 2015 EHPS SYNERGY Expert Meeting, our group examined the past, present and future of mHealth. This piece provides an overview of our discussions and offers guidance to EHPS members, including a summary of early successes within mHealth, promising avenues for ongoing research, and research challenges to address that could revolutionize the science and practice of behaviour change.

Early successes in mHealth

Successful SMS-based behaviour change interventions

SMS-based interventions have near universal reach, as all mobile phones can receive text messages, and there is considerable evidence for their effectiveness. Additionally, SMS message delivery is inexpensive, brief, automatic and can reach users in real time anywhere there is a mobile signal. Message content can be tailored to socio-demographics, behaviour, cognition, emotion, and user responses. For example, an SMS message could ask, "Are you in a situation that makes it hard to maintain your healthy lifestyle? Text back 'yes' or 'no'." A response of 'yes' would then trigger an SMS containing helpful situation-specific strategies. SMS messaging also allows users to actively seek support, by for example texting "crave" to the system, which could trigger a series of automated support messages and coping strategies.

Reviews of SMS-based interventions indicate that they may be more effective for simple behaviours (e.g. remembering appointments), than for complex ones (e.g. eating healthily or using sunscreen) (Orr & King, 2015). The frequency of SMS messages plays a role too, with multiple messages per day producing larger effect sizes than daily, weekly or one-off doses (Orr & King, 2015). Other factors do not seem to be associated with effectiveness of SMS interventions, such as target behaviour, user age, one-way versus two-way SMS (i.e. from interventionists to users and vice versa), and message tailoring. As there is growing evidence

of the cost-effectiveness of SMS-based interventions, and as many lessons learned from SMS-based interventions are readily applicable to interventions delivered via mobile apps, this should remain an active area of research.

mHealth apps: What works and the user experience

Mobile apps are now part of our everyday lives: from Google Play alone there are around a billion app downloads every month (Statista, 2016). This is impressive reach, but only a minority of apps retain users' engagement over the longer-term (Becker et al., 2013). A recent review on alcohol reduction apps suggests that self-monitoring, goal setting, action planning, and feedback components are positively associated with changes in behaviour (Crane et al., 2015), echoing the findings of meta-analyses in non-digital intervention contexts indicating the importance of self-regulatory processes. The review also indicated that ease of use and use of tailoring were positively associated with user engagement. However, qualitative research suggests self-regulatory BCTs like self-monitoring can be perceived as too effortful, and some users report concerns over context-sensing and data privacy (Dennison, Morrison, Conway, & Yardley, 2013; Gowin, Cheney, Gwin, & Wann, 2015).

More work is needed to uncover mechanisms of action that support effective engagement with health apps and self-regulatory processes to change health-related behaviours (Middelweerd et al., 2014). It is also vital that users' views and concerns are addressed to optimise design and delivery methods within health apps. Combining qualitative and quantitative methods can provide valuable complementary insights, and guidance is now available on how to rigorously apply qualitative methods in all phases of mHealth intervention development (O'Cathain et al., 2015; Yardley, Morrison, Bradbury, & Muller, 2015).

Novel data and methods to change behaviour

The portability and technical capability of smartphones open new avenues for understanding and changing behaviour, particularly in two key areas: detection and personalisation.

A system of connected sensors, wearables, phones and tablet devices offers an 'always on' method of collecting data. This creates a wealth of new data that can be collected with minimal burden for the individual, including detailed streams of time-stamped data on behaviour, use of intervention components, location, biological outcomes and social contexts (e.g. via social networks or electronically activated recorders (Mehl, Pennebaker, Crow, Dabbs, & Price, 2001)), all of which can be used to tailor intervention content to users.

As mobile phones and wearables also offer capacity for processing these data streams, and channels through which feedback, prompts and other BCTs can be delivered, highly tailored personalised interventions that 'know' and react to users' contexts, cognitions, behaviour and outcomes are within reach. Just-In-Time Adaptive Interventions (JITAIs) are one example: these use algorithms to collate data and deliver support and intervention components when and where they are needed most. While most JITAIs currently rely on decision rules and algorithms created a priori, machine learning techniques offer an alternative approach to personalising and optimising behavioural support. For example, collaborative filtering techniques can predict how an individual will rate the usefulness of a support message by using the ratings of other users with a similar history. The same could be undertaken to identify patterns of behavioural responses to elements of an intervention (e.g. spells of physical activity). This machine learning approach will likely produce JITAI algorithms and interventions that are far more personalized, adaptable and timely than what our present theoretical understandings ever could, and

will contribute to the creating the next generation of behavioural theories.

In addition to improving the effectiveness of interventions, new streams of data can help us to investigate theoretical motivational and behavioural processes within-persons in real time. Many behavioural theories were conceptualized at the within-person level, but previous research has largely used between-person methods to test theory. As between-person and within-person processes may differ (Hamaker, 2012), data from intensive longitudinal studies will allow us to investigate both simultaneously. These new data can help us to refine theories to include both between-person differences and within-person change processes, and help us to understand how psychological phenomena evolve over time. Finally, new technologies like GPS via smartphones enable us to integrate the role of the environment into psychological processes and theories as well.

Tools for creating and testing mHealth interventions

While developing and evaluating mHealth applications historically required considerable monetary investments and multidisciplinary collaborations between behavioural scientists, statisticians and computer scientists, new software tools have begun to streamline these processes. Open-source software tools including LifeGuide (www.lifeguideonline.org), Life Guide Toolbox (forthcoming via www.lifeguindeonline.org), Mobile Coach (https://www.mobilecoach.eu), and MyExperience (http://myexperience.sourceforge.net/) enable behavioural scientists with no programming experience to create e/mHealth interventions and mobile experience sampling applications. Control over intervention development reduces reliance on external programming expertise and therefore reduces cost, increasing accessibility to researchers with limited resources. Such platforms also allow for adapting and improving interventions iteratively based on user feedback and experience.

Some platforms also enable efficient adaptation and reuse of entire interventions (or their components) in diverse research and implementation contexts. Such modular systems and authoring tools can be integrated within virtual research environments (e.g. LifeGuide and Purple (Schueller, Begale, Penedo & Mohr, 2014)), and support collaboration and sharing of intervention components between disparate teams, thus avoiding the need to start from scratch for each new intervention. While these advances do not negate the need for collaboration with computer scientists and industry partners, they increase the number of individual researchers who can develop and test their own low-cost mHealth interventions.

Challenges in mHealth research

While advances in mobile technology hold promise of a new era for behavioural theory and intervention development, and use of more objective indicators of behaviour and health, these new opportunities also pose significant challenges.

Making sense of 'big data'

The vast amounts of data gathered by digital sensors and longitudinal ecological momentary assessments in mHealth interventions (i.e. 'big data') are often noisy and may contain missing data points. Producing robust analyses therefore requires well-informed cleaning or transformation, as well as a priori documented strategies to handle missing data. For example, erroneous signals must be removed from GPS data, and accelerometer data needs screening for spurious information. Modelling dynamic within-person processes over time requires complex statistical techniques, e.g. multilevel modelling and time series analyses (e.g. ARIMA), and so collaboration with statisticians

remains important. While challenging, using big data within simulation methods (e.g. agent-based simulation) presents new opportunities for predicting the dynamics of behaviour change over time. In agent-based modelling, an agent (e.g., a model of human behaviour selection and performance) is created, ideally based on psychological theory. Then, the simulation predicts the behaviour of the agent at a particular moment in time, in a specific context (e.g. in the presence of reminders, high social norms). For example, Tobias (2009), created and validated a theory-based agent-based model to test how reminders affect habit development over time. Such methods, however, require programming skills and emphasize the importance of collaborations with computer scientists.

Implementation and competing in a global marketplace

mHealth also faces challenges when it comes to reaching large audiences. At present, app stores are largely dominated by behaviour change apps developed in the private sector, which have minimal evidence of effectiveness. At the same time, behaviour change apps developed within academia may have evidence for their effectiveness, but cannot get easily distinguished among the thousands of downloaded apps. As search algorithms within app stores are based on number of downloads, number and quality of user reviews, app quality and social proof (likes/shares/+1s received via social media) (Butters, 2014), academically developed apps may languish in the lower realm of the search result hierarchy, creating a potentially misleading situation for end-users. To improve the visibility of our effective mHealth apps, we must connect with specialists in search engine optimization, be proactive in obtaining formal reviews from users, and make efforts in promotion and advertising outside of research settings.

Another challenge is the speed with which the private sector moves in relation to academia. In the private sector, ideas rapidly turn into new products and services, and user feedback and usage patterns are constantly fed back into the design and adaptation process. Within academia, however, new ideas require funding to get going, links with design and build teams must be forged and paid for to realize the work, ethical approvals must be obtained, and study results need to be written up and published in order to compete for subsequent funding. When combined, these time-consuming extra steps mean that by the time an academically-developed app has evidence for its effectiveness, its technology and user-facing components might already be outdated. To overcome this challenge, behavioural science teams should partner with experienced software developers and experts in human-computer interaction (HCI) to streamline these processes, though this inevitably increases costs.

Interdisciplinary working and collaborations with industry

Partnerships between behavioural science, computer science and HCI are key to developing and evaluating useful, usable, and rewarding digital interventions. As behavioural and computer sciences use very different language, models and concepts, successful collaboration requires an openness to learning about each other's concepts and terminology, ways of working and incentives, as well as knowing what each field brings to the table in terms of evidence, theories and methods. This process is challenging, but the prizes are great in terms of fostering innovative 'transdisciplinary' thinking and providing new insights that would not be possible within monodisciplinary silos.

When collaborating with industry on mHealth projects, it is important to clearly communicate how our expertise as behavioural scientists shapes our intended vision for projects and make this

accessible and usable by industry partners. Conversely, it is equally important that industry partners grasp the importance of collecting data in forms that can be used to advance behavioural science. Below are a few tips to foster collaborations with industry when applying behavioural science in practical settings (Additional tips in Pronk et al., 2015):

1.Recognize the different incentives/goals of partners, including risks. While academics primarily wish to further knowledge and disseminate this in peer-reviewed journals, companies may be primarily focused on financial profit.

2.Work to unify timelines. Industry is often driven by rapidity (e.g. 'fail fast', 'sprints') whereas academia emphasises systematic and rigorous methodologies which can take months or years to produce evidence.

3.Clarify channels of communication/ collaboration. The skills required for successfully working across sectors are complex and are not a part of the academic curriculum in behavioural science. Define the preferred means of communication to help things move smoothly.

4.Monitor progress regularly, both positives and negatives. Identifying (potential) issues in the collaboration as early as possible can help to ensure all parties get what they want out of the project. Similarly, identify positive aspects as something to celebrate.

What role can the EHPS and its members play?

Developments in mHealth research will further advance health psychology and behavioural science, but several challenges must be overcome to realise the full potential of these technologies. For further reading on the topic, see the other papers in this special issue, as well as a recently published series in the November issue of the American Journal of Preventive Medicine which focused on digital health interventions (Yardley, Choudhury & Patrick, 2016). In our view, the EHPS and EHPS members can take leading roles in several key areas (Table1), and we look forward to driving developments within the field.

Table 1

Potential Roles of the EHPS:

- Offer networking events to help foster connections across disciplines
- Help to improve the ability of health psychologists to work competently within and across (currently) disparate disciplines.
- (Continue to) offer training in mHealth methodologies, advanced statistics, intervention development, and technical mHealth topics

Roles of EHPS Members:

- Improve use of open-science frameworks and resource sharing.
- Further develop existing digital platforms to enable flexible, iterative development of mHealth functions
- Foster strong collaborations with computer science and industry partners
- Be the future of mHealth research! Harness individual-level methods (e.g. n-of-1), mixed-methods approaches, and dynamic models of behaviour based on big data to unravel momentary processes and mechanisms of action

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original article

Interactive Voice Response: A highly tailored mobile health method to promote behavior change.

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In the UK, adults report spending 226 billion minutes per year in voice calls (OfCam, 2015), which highlights the huge potential of phone platforms to reach people and generate large amount of data. Automated phone-based tools, such as Interactive Voice Response (IVR), can enable health behaviour change and generate novel data on the underline factors of behaviour change and maintenance in a limited time. However, to date the vast majority of such interventions have been developed and tested in the USA. This article is an overview of the development and pre-test of the first IVR intervention within the UK to support medication adherence.

What is Interactive Voice Response?

Interactive Voice Response (IVR) is an automated, phone-based platform that facilitates health care communication using speech files. A series of highly quality pre-recorded chunks of information are delivered to participants' mobile phones and/or landlines. Participants use their keypad or microphone as an interface to exchange information with an interactive algorithm.

IVR platforms were introduced in the early seventies, and since then their definitions have varied depending on their architecture and the purpose of use. IVR platforms can be structured to contain from a single prompt to multiple navigation options. The degree of interaction can also vary significantly between platforms. Some IVR systems facilitate one-way communication, where no features for participants' response are integrated, whereas other platforms integrate software that enables participants' engagement in a series of dialogues. IVR platforms can also vary in duration and include from very brief to lengthy audio files.

IVR was initially used as an automated interviewing technique to screen medical symptoms and collect survey data (Piette, 2000; Piette et al., 2015). In later versions IVR was integrated into the health care to interchange clinical data between patients and practitioners, aiming to reach those patients in lower socioeconomic backgrounds with limited access to healthcare. In its simplest format, patients reported clinical data (e.g. blood glucose levels) or symptoms to the IVR system. More complex IVRs incorporated decision support systems to facilitate real-time adjustments to health care (e.g. adjustment in medication dosage).

One of the advantages of IVR that appealed to those with poorer health or literacy is the use of speech instead of text. Speech data require less effort than traditional writing techniques, allowing articulation of thoughts and facilitating multi-tasking. On the other hand, more complex information might be more difficult to comprehend when heard rather than read. The high acceptability of IVR is also associated with the flexibility of the platforms to run automatically, continuously, be adaptable to participants' pace

and allow patients' elaboration of their perceived treatment needs and priorities, in addition to the increased anonymity and confidentiality to sensitive information.

IVR and Behavior Change: the use of Theory and Behavior Change Techniques

Given its popularity, IVR has recently been used as a platform to deliver behaviour change messages (Kassavou & Sutton, 2016). However, it is largely unknown whether IVR interventions can be effective at changing behaviour, let alone the mechanisms that account for their efficacy. To answer this questions, we conducted a systematic review of randomized controlled trials. We found 14 trials, the great majority of which were conducted in North America. Meta-analytic results suggested that IVR interventions can effectively promote changes in medication adherence and physical activity but showed limited efficacy in changing diet and alcohol consumption. We further looked at the features of the IVR interventions that might impact on their efficacy and assessed the use of theory and behaviour change techniques (BCTs) (Michie et al., 2013).

To assess the theoretical basis of the interventions we used a theory coding frame of five criteria with "yes" or "no" responses based on the Michie and Prestwich (2010) framework for coding theories. Studies were assessed in terms of whether: (1) a theory/theoretical construct(s) or techniques were mentioned in the introduction, (2) an explicit description of how intervention technique(s) were linked to theoretical construct(s) was described, (3) changes in theoretical constructs, as result of the intervention were measured, (4) mediation effects of any/all theoretical constructs on behaviour were measured, and (5) findings were explained in relation to theory/ theoretical construct(s) or suggestions were made to refine theory.

Out of the 14 included trials, 10 discussed a theoretical construct, theoretical model or other theoretical approaches in relation to the content of the intervention. Four studies mentioned the use of multiple theories, and five studies used a single theory or theoretical approach. Specifically, the Transtheoretical Model was mentioned in four studies; Cognitive Behavioural Therapy was mentioned in three studies; each of the Theory of Planned Behaviour, Social Cognitive Theory, beliefs regarding medications, and Motivational Interviewing was mentioned in two studies; and each of the Social Norms Theory, Planning, Health Belief Model, Chronic Care Model, Reflective listening, and Communication Theory was mentioned in one study. However, none of the included studies satisfied all, or even half, of our coding criteria. Only one study, which was informed by five different theoretical approaches, measured changes in one of the targeted theoretical construct at baseline and follow up. None of the interventions tested the mediating effect of theoretical construct(s) to produce effects on the targeted behaviour, which emphasizes our limited knowledge on the underlying mechanisms that produce changes in response to IVR interventions. Nevertheless, when we coded the BCTs we identified a range of techniques, with each IVR intervention including between two and 19 BCTs delivered within a voice message lasting between 40 seconds and 10 minutes. These results highlight the potential of IVR interventions to deliver complex behaviour change messages in a very brief period of time.

IVR to support medication adherence

We designed a new IVR platform to provide

highly tailored advice and support to address each patient's reasons for medication non-adherence. Our decisions on the structure and the topography of the platform were informed by consultations with telecommunication experts in the University of Cambridge and discussions with experts in the industry. The IVR system has been structured to flexibly implement from simple prompts to more elaborative dialogues. Participants have the option to listen to more complex messages repeatedly, and can provide their input during the intervention and at a time they prefer to interact with the IVR system (e.g. by triggering an inbound call). Participants can further tailor elements of the delivery mode (e.g. frequency of the calls) and the intervention content (e.g. requesting additional or different information) using the voice recognition software.

We pre-tested the acceptability of the IVR system with 13 people with long-term conditions (i.e. Hypertension and/or Diabetes type 2), recruited via primary care databases. Participants were asked to trigger IVR calls, interact with the IVR system and provide experiential feedback on the delivery mode and intervention content. Participants enjoyed the pitch and the tone of the voice delivering the messages and the flow of the dialogue. They found the voice warm, friendly and easy to distinguish from cold calls. Moreover participants reported preferences on female voices and of greater volume. They all reported being satisfied with the voice recognition software and the available options to tailor the intervention content and delivery to their perceived needs. Moreover, participants made recommendations on the structure of the platform (e.g. navigation options), the delivery style (e.g. duration of each call) and provided input on message content. Based on the participants' input and theory we developed the intervention content and delivery mode, and we will further test the feasibility of the IVR to support medication adherence to people with long term condition recruited by primary care practices.

Future research and conclusion

Mobile devices have the potential to act as highly tailored tools to automate informed healthcare. Still, without rigorous evidence on the mechanisms of behaviour change, the type of targeted behaviour and the outcomes of the change produced, our understanding on how we can promote behavior change will be limited.

IVR has the capacity to support patients' process of initiation and maintenance of behaviour change in real time, and to bring new perspectives to existing theories, by providing objective data on the process that account for sustained behavior change. Speech data can be analyzed to objectively identify participants' emotions and provide tailored advice to further facilitate articulation of thoughts. Future interventions could integrate voice recognition and sensors of behavioural enactment (e.g. ingestible pill sensors, wearable patches, refill medication records, accelerometers) to trigger highly tailored messages and enhance participants' behavioural performance. Future intervention could usefully integrate the IVR to other delivery modes, such as face-to-face consultations and text messaging to facilitate effectiveness and potential assessment of the cost-effectiveness of behavior change interventions. Moreover, integration of objective clinical outcomes could lead to better insights into health care communication and optimize therapies.

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original article

Using technological interventions to elicit behaviour change: the development of a text message intervention.

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Introduction: Mobile health

The new generation of health interventions are moving towards digitised innovative methods which seek to support people to better manage their health condition or as an educational tool to support change. There are several approaches introduced to date such as web based interventions or mobile "apps" which are increasing rapidly. Recently the rise of mhealth has given researchers, psychologists and developers a range of examples which portray, "good" methods of delivering such interventions, but what have we learnt from this and how does this further our understanding of digital health. Although, there is no static method of developing such programmes and each are unique to the sample it is addressing, but there are some basic protocols we need to consider.

As an example, to illustrate this process the discussion will focus on the development of a text message based intervention for patients diagnosed with Inflammatory Bowel Disease (IBD).

Using text messages in health interventions

Tailoring short text messages based on patient's illness and medication beliefs has shown significant improvements in medication adherence (Horne & Weinman, 2002). We know that intentional and unintentional medication adherence is problematic for patient's remission and cost of non-adherence is significant (DiMatteo, Giordani, Lepper & Croghan, 2002). There are several adherence models which attempt to identify different aspects of patient behaviour and the underlying belief structure. Leventhal, (1987) common sense model of illness representation suggests that self-regulation is a function of the representation of health threats and the coping mechanisms adopted by the individual. This suggests that patients with the same condition hold disparate views surrounding their illness, which may explain why some people are adherent and other are not. (Leventhal, Diefenbach, & Leventhal, 1992). Similarly, the Necessity Concerns Framework (Hornes, et al, 1999, Hornes, 2006) measures an individual's illness beliefs and the necessity of medication, which can explain their beliefs associated with non-adherence. Understanding the theory and implementing this into an intervention will help support the robustness of the programme, which we did for the IBD programme.

The process will be explained and hopefully offer readers an understanding of what needs to be done to produce similar interventions. Learning and improving is a significant milestone in Health Psychology research and what we should take away from this is technique to improve future research.

IBD Programme

IBD is a chronic bowel condition and consists of Crohn's and Ulcerative Colitis. Research suggests that identifying an individual's illness beliefs and medication concerns can help shift the beliefs which then improves various other domains such as quality of life, adherence to medication and better

overall self-management of the condition (DiMatteo and Giordani, et al, 2002) However, what does this look like?

The methodology

Developing a text message initiative is a delicate and timely process, there are many factors to consider, such as types of messages, frequency, personalisation and measurable outcomes. Once these variables were defined, the personalisation process then followed. The important element of the IBD programme was to ensure that it was bespoke to the individual, as it was addressing their personal beliefs and illness perceptions of their condition. Remember, this is unique for everyone, and to successfully understand their need participants completed a pre-screener measure using the validated Brief Illness Perception Questionnaire (B-IPQ) and Necessity-Concern scale assisted the personalisation process, from this we could categories the messages based on the measurement domains. It is important to include some type of measurement within the design; this will ensure that the programmes objectives are in line with the outcomes and aims to elicit a "real" change.

Measures

A robust measurement strategy was developed which was used to monitor the effectiveness of the programme. This included a list of validated measures which were used with each participant at the start of the intervention and at the end of the 12 weeks. Text messages were specific to the targeted beliefs as exampled in table 1 and 2. Each belief consisted of 7 messages, with a total of 112 messages. Once the bank of messages were developed the next step was to draft the timeline and frequency of these messages. This can be difficult particularly because you don't want to lose the momentum of ensuring that the messages are meaningful and helpful as appose to inconvenient. Therefore, based on habit formation research, it was decided that the frequency would vary over the course of 12 weeks. In fact, this worked considerably well and participants enjoyed the change in frequency and times of when the messages were sent.

Table 1

Example extracts of text messages mapped onto the illness beliefs questionnaire

IPQ Domains	Example text messages
Identity (low)	"Coming off your medication is likely to worsen your symptoms"
Identity (high)	"Abdominal pain, diarrhea, weight loss and bloody stools can be managed if you follow your treatment plan, this will improve your symptoms"
Consequences (low)	"Crohn's Disease is a condition that needs regular care and attention"
Consequences (high)	"Managing your Crohn's Disease means getting on with life"
Timeline (short)	"Your Crohn's Disease is always there even when you don't have symptoms" "Your Crohn's Disease will always be there but you can learn to manage

Table 2
Example extracts of text messages mapped onto the BMQ (medication beliefs questionnaire)

BMQ Domains	Example text messages
Personal control (low)	"Control your Crohn's, don't let it control you"
Personal control (high)	"I'm doing my best to cope with my Crohn's"
Treatment control (low)	"Using medication reminders can help you control Crohn's Disease"
Treatment control (high)	"Being in control of your medication means you are likely to benefit from symptom reduction"
Concern (low)	"Studies have shown that patients' quality of life worsens during relapse"
Concern (high)	"Worrying rarely helps people to come up with solutions. Your worrying just goes in circles"

To ensure that the messages were sent to the participants on time, segmentation and timescales were developed which was filtered into the text messaging system. Within this template exact times and days of messages were outlined and to which participant for as outlined in table 3.

This method instilled accuracy and allowed the researcher to monitor which messages were being sent to avoid repetition.

Table 3
Process of messages

Participant	Am	Pm	Text message
1		X	"Being in control of your medication means you are likely to benefit from symptom reduction"

Was this programme useful?

Offering a personalised programme as an alternative to the traditional method of delivering health interventions is beneficial, this was evident from the IBD programme. Participants appreciated the novel method of receiving messages which resonated with them as messages were specific to their needs. The IBD programme was successful and evidenced an increase in medication adherence and a change in illness perception and beliefs. Although the method of personalising is extremely timely the outcome is beneficial.

What are the important things to remember?

1.Mobile interventions should be theoretically driven, therefore offering a robust framework to develop an effective programme.

2.Text messages should be relevant and consistent with the belief they are targeting.

3.Remember to change the frequency of the message and avoid repetition within the same week.

4.Develop a measurement strategy built into your programme this will help record the outcome and determine if a change really occurred.

5.Text message programmes may not always be the best option offered and is dependent on the sample it is targeting. This needs to be considered when deciding on the methodological approach.

6.Text message interventions can be offered as a sole product as we did for the IBD programme or compliment an interventions as an additional tactic.

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original article

Mobile Health Development – The Need For a Rigorous Approach.

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The exponential growth of mobile health (mHealth) apps have converted smartphones into tools for medical education and functions (e.g. medical reference apps, clinical decision support apps), self-management of chronic conditions (e.g. diabetes apps) and especially, health promotion (e.g. weight loss apps). With regards to their development, there is growing consensus that mHealth interventions should be based on evidence, behaviour change theory and formative research with the target population (Buller et al., 2013; Whittaker, Merry, Dorey & Maddison, 2012; Stroulia et al., 2013; Fjeldsoe, Miller, O'Brien & Marshall, 2012). Moreover, underpinning interventions with theory is a key recommendation of the UK Medical Research Council's framework for developing and evaluating complex interventions (Craig et al., 2008). Indeed, behaviour change is central to advancing 'implementation of evidence based practice and public health', where 'Behaviour change interventions' are defined as 'coordinated sets of activities designed to change specified behaviour patterns' (Michie, van Stralen & West, 2011:1).

While there is a need to incorporate evidence and theory into behaviour change mHealth interventions, other important aspects to consider, relate to their social validity and acceptability amongst stakeholders (Danaher & Seeley 2009). This is especially pertinent in the case of apps where approximately 26% of all apps downloaded are discarded after first use (Localytics 2011). Consequently, there is a growing trend towards adopting a user-centred design approach (UCD), a participatory design approach focusing on the user and on 'incorporating the user's perspective in all stages of the design process' (Devi, Sen & Hemachandran, 2012:1).

The importance of including engaging design principles also requires consideration, where current evidence implies that mHealth apps with more evidence-based strategies are amongst the least popular with consumers (Pagoto, Schneider, Jojic, Debiasse & Mann, 2013). This may suggest that commercial mHealth apps, compared to research led apps are designed in a way that promotes greater engagement for consumers, despite their lack of theoretical content. For example, commercial app companies may use more engaging design features with regards to aesthetics and interactive components. Arguably then, mHealth development would benefit from greater collaboration between experts in behaviour change and the commercial app industry to help address these gaps (West et al. 2013; Curtis & Karasouli, 2014). Taking all of these factors into account, I will now demonstrate how I addressed them drawing on two case studies of mHealth apps where appropriate: Health Heroes (a family healthy eating app: (Curtis et al. 2015) and MyMate (a medication adherence app for children with sickle cell disease: (Lobitz, Curtis, Lebedev & Sostmann, 2016).

Theory and evidence

To ensure both apps were underpinned by relevant theory and evidence, a comprehensive

intervention design method known as the 'The Behaviour Change Wheel' (BCW: Michie, Atkins & West, 2014) helped direct the app development process. The BCW is a highly practical resource that guides you on: how to define the problem; select the target behaviour and audience and; understand the problem. Hence, at the core of the BCW is the Capability, Opportunity, and Behaviour Model (COM-B: Michie et al., 2011) which allows you to carry out a detailed behavioural analysis of the problem. The BCW then helps you to map the theoretical conditions identified from the behavioural analysis to direct intervention components for changing behaviour (see Curtis et al. 2015, for a detailed step by step guide on how the BCW was implemented for app development). The results of this stage are summarised for the two case studies in Table 1 below.

User-Centred Design

One approach to increasing target audiences' engagement with the app is to ensure that the app incorporates their preferences and requirements for app features using a user-centred design approach (UCD). According to Rogers, Sharp and Preece (2011), in a UCD approach 'while technology will inform design options and choices, it should not be the driving force' (2011:327). The advantage of

Table 1

Stage 1: Underpinning the app with theory and evidence

Define problem	Target group	Method for involving target group & Analysis	Overview of Behavioural Analysis
Too many overweight children in the local area (UK based)	Parents	Focus groups. Thematic Analysis using framework	Parents revealed their: limited knowledge and skills around age appropriate portion sizes (Capability); fear of eating disorders and low confidence in making dietary changes (Motivation); and environmental influences relating to a household objects and social influences such as Grandparents (Opportunity).
Children with SCD not regurarly taking their medication (Germany based)	Children	Interviews. Thematic Analysis using the COM-B as a coding framework	Children had a limited knowledge of the disease and self-management steps as well as lapses in their memory for taking their medication (Capability); the belief that medication does not make a different to their health and religion is more powerful; a lack of confidence in self-managing their condition; emotions of stress and anxiety increasing their pain symptoms (Motivation); a limited time to take medication; a high reliance on parents for reminding them to take their medication and; other health professionals who lacked knowledge on how to treat their condition (Opportunity).

considering usability issues early on in the engineering lifecycle of the app includes enhanced predictability, greater efficiency with less errors, better alignment with user needs and savings in resources (i.e. development period and budget) (Yen & Bakken 2009). While there are many ways to incorporate a UCD approach for intervention development (e.g. Dennison, Morrison, Conway & Yardley, 2013; Hebden, Cook, van der Ploeg & Allman-Farinelli, 2012), Rogers et al. (2011) interaction design model helped to guide the app development process. An inductive thematic analysis was then conducted to identify key themes. Therefore, the app development process conducted formative research with the target population simultaneously on the theoretical, user-centred and technological aspects (using focus groups and interviews) which were then revisited, adapted and refined through an iterative and cyclic design process.

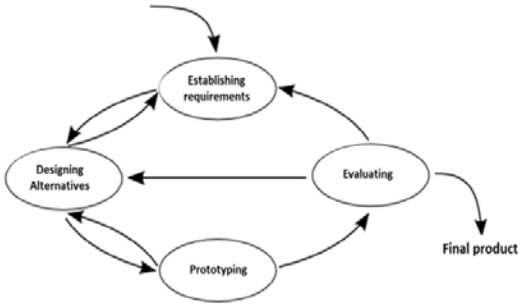

Figure 1. A simple interaction design model (Rogers et al., 2011)

Collaboration with industry

Drawing on the steps in the BCW, theoretical conditions are then mapped onto potential intervention strategies and combined with the first stage of UCD approach (i.e. user preferences for app features). This helps to translate intervention strategies (which are in the form of behaviour change techniques) into engaging app features. At this stage, it is important to include the app development company (i.e. the digital media industry) in the process as they are essentially the experts in designing fun and engaging app features.

Once you have developed your design concept and proposed app features, you can then test these out on your target audience using interactive mock-ups of the app. Interactive-mock ups refer to wireframing software that can help designers to develop prototypes of interactive products such as websites or smartphone apps. They allow users to interact with them by clicking on icons and images that take them through to another area in the design, reflecting how it would work in practice. The aim of testing is to receive feedback on the overall concept of the app and specific app features which, in turn, provide insight into the acceptability of certain behaviour change and gamification techniques. Focus groups and interviews also provided the opportunity to explore certain elements of usability and user experience. Although there is no precise model that encompasses all the possible usability and user experience elements to explore with participants, Preece et al., (2002) model provides a good overview of usability and user experience goals to explore with participants as they gave feedback on the app.

The next iteration of the app involves the development into a prototype app. Testing at this stage consists of utilising an informal inspection method known as the 'think-aloud' method, which permits a 'good compromise between cost and implementation time on the one hand, and the results they make it possible to obtain on the other'(Yen & Bakken, 2009:714). In addition, a quantitative usability survey can be administered to participants using the app for a period of two weeks. This is a really good method for allowing the app company to identify numerous bugs and

Table 2

App	*Summary of UCD findings*	*Example Behaviour Change Technique*	*Example Design Feature*
Health Heroes	Parents' preferences for healthy eating app features included quick and easy to use, minimal data input, visual aids of food and receiving points for healthy eating (gamification).	Self-monitoring of the behaviour	A simple portion tracking tool that awards points for logging food. 
MyMate	Children's preferences for app features included: reminders; features to distract from the pain such as a game and breathing exercises and; having a virtual character to look after.	Prompts/cues	Avatars remind children to take their medication 

usability issues.

Once improvements have been made to the app based upon the previous steps, the next phase in this approach is to test it in a natural setting with the target population to understand how they interact with the app. In line with the MRC guidance on evaluating complex interventions (Craig et al., 2088), this stage could involve modelling the process and outcomes of the app in changing behaviour. Following a similar method used by Willey and Walsh (2016), a quasi-experimental research study could be conducted, using a single arm pre and post-test assessment of the primary outcome (e.g. portion sizes/ medication adherence) and secondary outcomes (e.g. weight and hypothesised theoretical domains).

Conclusion

Within the context of mHealth interventions we cannot ignore the reality that theoretical, user-centred and technological components are inexorably linked. There are still significant gaps in our knowledge regarding which components of apps are effective for behaviour change and whether apps, as a medium, are even effective for behaviour change; as well as which target populations certain components might work best for. However, partnering with the digital media industry and following a systematic development process that draws on relevant theory, evidence and research with the target population will undoubtedly help to address these gaps and advance the field of mHealth.

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original article

Strength In Numbers Hackathon: Using a novel technology-focused brainstorming activity to engage stakeholders in intervention development.

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Young adulthood has been identified as a particularly challenging time to live with and manage a chronic condition, like type 1 Diabetes (McKnight, Wild, Lamb, Cooper, Jones, Davis et al., 2015; Wiebe, Helgeson, & Berg, 2016). A growing body of research shows that living with type 1 Diabetes as a young adult is associated with more Diabetes-related problems as well as reduced wellbeing (Bryden, Dunger, Mayou, Peveler & Neil, 2003; National Health Service, 2015). Despite growing awareness of the risks faced by young adults with type 1 Diabetes, there is a lack of evidence-based guidance in the research for supporting young adults to improve self-management and outcomes (O'Hara, Hynes, O'Donnell, Nery, Byrne, Heller & Dinneen, 2016).

Addressing the needs of young adults: The D1 now study

The findings of an audit of the Young Adult Diabetes Clinic conducted in Galway University Hospitals confirmed poor outcomes similar to reports from other parts of the world and demonstrated the need to engage differently with this population (Casey, O'Hara, Cunningham, Wall, Geoghegan, Hynes et al., 2014). The research team was awarded a Health Research Award by the Health Research Board (HRB) in Ireland to establish an evidence base for developing a new intervention for young adults living with type 1 Diabetes, the D1 now study.

Based on the development phase of the Medical Research Council Framework for developing and evaluating complex interventions (Craig, Dieppe, MacIntyre, Michie, Nazareth, & Petticrew, 2008), four work packages were completed. To identify the evidence base related to improving outcomes among young adults with type 1 Diabetes, a systematic review of all interventions aimed at improving clinical, behavioural and psychosocial outcomes for young adults with type 1 Diabetes was completed (O'Hara et al., 2016). A qualitative study was conducted involving interviews with parents of young adults with type 1 Diabetes and diabetes service providers, and focus groups with young adults to develop a theoretical understanding of the drivers of young adult self-management (Hynes, O'Hara, Casey, Murphy, Byrne, & Dinneen, In prep). Utilising a methodology from behavioural economics, young adults' preferences

for characteristics of Diabetes clinics, and the delivery of education and support services, were assessed using a Discrete Choice Experiment. The final work package was to establish and integrate a Young Adult Panel (YAP) of Diabetes service users. Jigsaw Galway is a local youth mental health organization with an extensive track record of meaningful engagement with the young adults using their services. With the support of Jigsaw Galway, an eight-member Public and Patient Involvement (PPI) panel of 18 to 25 year olds living with type 1 Diabetes was recruited. The YAP have made significant contributions to all aspects of the research including development of research materials and dissemination.

Engaging stakeholders in intervention development

Recommendations for designing behaviour change interventions emphasize the importance of the development phase and collaboration with experts, particularly relevant stakeholders, to translate the evidence-base into a potentially effective intervention (Craig et al., 2008; Mc Sharry, Fredrix, Hynes, & Byrne, 2016). A consensus event, called the Strength In Numbers symposium was organized with the support of a Knowledge Exchange and Dissemination Scheme Award from the HRB, to gain stakeholder input into the D1 now intervention development process. The main conclusions drawn from the systematic review, qualitative research, discrete choice experiment and YAP engagement was that a new approach to working with young adults was needed and that this approach would need to be innovative, prioritise self-management support, harness the power of digital technology and social media, and engage young adults throughout the process.

The symposium took place over three days and involved over 110 delegates, 10% of whom were individuals living with type 1 Diabetes. Delegates also included Diabetes service providers, technology experts, policy-makers and researchers. The symposium included three main activities; a Core Outcome Set Consensus meeting (funded by a New Foundations Award from the Irish Research Council) to identify outcomes which should be included in all future young adult type 1 Diabetes research, a conference, and an expert panel meeting. The expert panel meeting involved two parallel meetings, one focusing on reaching consensus regarding strategies for improving young adult self-management, and the other on identifying technology solutions to fit within an intervention, through a brainstorming activity called a Hackathon.

The Strength In Numbers Hackathon

A Hackathon is a dynamic, collaborative approach often used in the development of start-up technology businesses that brings together a diverse group of people with the relevant skills to create an output. Their use in healthcare innovation is increasing (Silver, Binder, Zubcevik, & Zafonte, 2016). Hackathons capitalize on the fact that many healthcare innovations are borne out of individual experience, for example a doctor trying to solve a problem. Supported by experts from the Irish Health Services Executive Office of the Chief Information Officer, and from the NDRC, the D1 now team chose to use the Hackathon format as a rapid and engaging approach to translating findings from the developmental phase of the research into feasible and innovative technology solutions. Harnessing digital technology to support self-management is widely regarded as an important approach and one that is particularly relevant for young adults (Yardley, Choudhury,

Patrick, & Michie, 2016; Monaghan, Helgeson, & Wiebe, 2015).

Hackathons are based on ideas developed in response to a clear problem statement with input from a diverse team. The planning and implementation of the Strength In Numbers Hackathon was guided by the Health Hackathon Handbook (MIT Hacking Medicine, 2016). The Strength in numbers Hackathon involved 28 participants, including representatives from Irish and multinational technology companies, local and national hospitals and universities, and eight young adults with type 1 Diabetes. Hackathon participants were provided with a summary of the findings of the D1 now study and a description of three modifiable focus areas identified based on the research findings, two weeks in advance of the Hackathon, to facilitate the development of their ideas. The three focus areas were: 1. The way young adults are introduced to the adult Diabetes clinic, 2. Attendance at Diabetes clinic appointments and contact between appointments, and 3. Building

Strength In Numbers Conference delegates

relationships between young adults and service providers.

The Hackathon participants attended the Strength In Numbers conference on day two of the symposium to gain a deeper understanding of young adult type 1 Diabetes self-management and engage in discussions with other delegates. The Hackathon began on day two of the symposium immediately after the conference. The first part was a brainstorming session to generate ideas from the participants and started with young adults living with Diabetes describing opportunity and problem areas. As ideas were shared the IT experts suggested where technology may form part of the solutions to address those areas. The next phase was an open discussion on the ideas and potental solutions to converge on four or five ideas, with participants self-selecting into working teams based on having a minimum of one of each key stakeholder: a young person with Diabetes, a

D1 now Young Adult Panel members

Diabetes health practitioner, a health psychologist, and a technologist.

The following day teams began work on their proposals early with mini-milestones set to ensure teams clarified their target users, related their proposal back to the behaviour change evidence base, and they tracked towards a well-developed pitch.

Group work discussing intervention strategies during the Strength In Numbers Expert Panel meeting

The Hackathon produced four ideas intended to fit within an intervention. The four ideas are described

Table 1

Hackathon proposal descriptions

Hackathon Team Name	Proposal description
Transition App	Platform & aim: Mobile app aimed at aiding timely transition from paediatrics to adult diabetes services. Setting: Paediatric diabetes clinic, school and social contexts, such as sports clubs. End-users: Parent and/or young person with type 1 diabetes Features: App is accessed through diabetes clinic WiFi. The app aims to enhance relationships between young people and their service providers, allow young people to access high quality educational content on the go, provide motivational advice from influencers and deliver rewards via gamification to encourage better self-management. Implementation: The reach of the app to its target population will be maximised using social marketing expertise.
Injection, Pumps, Understanding and Management (IPSUM)	Platform & aim: Mobile app and web portal for enhancing communication between young adults and service providers. Setting: Daily self-management End-user: Young adults with type 1 diabetes and service provider Features: App helps young adults log and monitor their carbohydrates, exercise, alcohol and blood glucose levels. Includes an in-built calculator to help determine insulin dose adjustments. Data will be visualised on a web portal to assist with clinic consultations and used to monitor trends to help reach collaborative goals between young adults and service providers. Implementation: App will be integrated with other smart devices (such as accelerometers and other wearables) to minimise manual input requirements from the young adults.
SnapD1	Platform & aim: Channel on the popular social media app called Snapchat, which sends young adults personalized motivating and informative content Setting: Daily self-management End-users: Young adults with type 1 diabetes Features: App integrates personalized motivational and educational content with a social network of peers with type 1 diabetes. App can send reminders, facts and top tips as well as providing young adult generated content and motivational pictures and comments.
DiaLog	Platform & aim: Website or mobile app to improve communication between young adults and service providers, and empower young adults as they transition to adult diabetes services. Setting: Paediatric diabetes clinic End-user: Young adults with type 1 diabetes and service providers Features: App allows young adults to find out about service providers present at each clinic visit and provides a platform for a 2-way communication between the diabetes clinic team and young adults. Young adults would complete a pre-consultation checklist asking how they are feeling and some questions they would like to discuss during visit. Implementation: App is activated when the hospital WiFi is accessed and includes a range of features for making the most of clinic visits by tailoring to individuals.

Core Outcomes Set Consensus meeting

in table 1. Mobile applications, some with accompanying websites, were the most popular platforms. Of the four proposals, only one involved the use of an existing platform, Snapchat, to create a social network of young adults with type 1 Diabetes. Transition from paediatric to adult Diabetes clinics was the focus of one of the applications proposed, while communication with service providers was the focus of the other two applications.

Each Hackathon team pitched their idea to the expert panel, who then chose the winner of the Best Pitch Award. Pitch development and delivery, and lively competition are key characteristics of Hackathons. The team who developed the proposal for SnapD1 were voted the winning team, and included a Diabetes Nurse Specialist, PhD student in health psychology, a young adult living with type 1 Diabetes, an IT consultant, and a start-up developer/biomedical engineer.

The Strength In Numbers Hackathon experience and future directions

The Strength In Numbers Hackathon, and symposium as a whole, was a rewarding and enlightening experience and facilitated the D1 now research team to produce a proposal for a complex intervention to improve self-management among young adults with type 1 Diabetes. In the next phase of the study the proposed intervention will be further refined, before beginning a pilot randomised feasibility study.

A growing body of research demonstrates the need to change the way diabetes services are delivered to young adults with type 1 Diabetes, as well as other chronic conditions such as asthma and Cystic Fibrosis (O'Hara et al., 2016; Okumura, Ong, Dawson, Nielson, Lewis, Richards, Brindis et al., 2014). Health psychology has much to contribute to facilitating the use of novel approaches such as Hackathon to translate evidence into intervention components. Iterative processes of development, engagement with stakeholders, testing and adaptation are recommended to develop effective mHealth interventions, which contribute to the evidence base as well as achieve positive outcomes (Yardley, Spring, Riper, Morrison, Crane, Curtis, Merchant et al., 2016). Through continued engagement and collaboration with the stakeholder network created through the Strength In Numbers Hackathon, the D1 now study aims to enhance engagement between young adults and service providers, to improve self-management and to ultimately impact on diabetes and psychosocial outcomes of young adults living with type 1 Diabetes.

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Statement of competing interests

None

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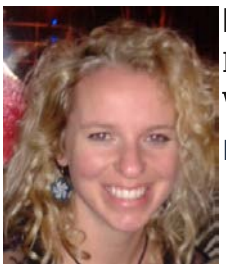

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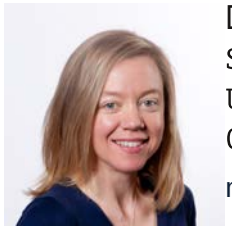

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original article

Behavioural mHealth in developing countries: what about culture?

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Non-communicable diseases in developing countries: the giant problem

Non-communicable diseases (NCDs) such as diabetes and cardio-vascular diseases are a serious global health problem of modern times. The burden is especially high in developing countries which account for more than 80% of NCD-related deaths (Lozano et al., 2012). With this NCDs are slowly but surely outgrowing infectious diseases in terms of its impacts on morbidity and mortality in developing countries. These are grim facts, but fortunately the answer to the question of how to deal with the NCD epidemic is already well established in the research literature and beyond: Live a healthy life – which most commonly translates to get active and eat healthily (Sallis et al., 2016; World Health Organization, 2014). And this is where the problem lies. Rapid urbanisation and development made many forms of work- and travel-related physical activity unnecessary for many people living in developing countries (Lachat et al., 2013). Additionally, healthy local foods are increasingly replaced by processed foods high in salt, sugar and fat (Baker & Friel, 2014). In light of the struggles of fragmented and under resourced health-care systems that cannot cope with the increasing burden of NCDs, interventions that promote healthy lifestyles are urgently needed.

Behavioural mHealth in developing countries: search for culture

In the absence of political action to address behavioural health in many developing countries (Lachat et al., 2013) one could suggest to simply make use of infrastructure that is already available – the mobile technology infrastructure. This seems sensible considering that modern mobile technology has reached almost every person on our planet. Additionally, the digital divide between developed and developing countries is closing and in 2016 95% of the global population has access to a mobile phone network while the number of mobile broadband subscriptions grows rapidly especially in developing countries (International Telecommunication Union, 2016). Mobile technology ownership is also not limited to any specific demographic because it is increasingly affordable and hence, there is potential to utilise behavioural mHealth approaches to successfully deal with NCDs in developing countries (Beratarrechea et al., 2014; Stephani, Opoku, & Quentin, 2016).

This makes all perfect sense but unfortunately it doesn't mean that the inherent potential of mHealth to combat NCDs in developing countries is well explored. In our recent review on e- & mHealth interventions to promote physical activity and healthy eating in developing countries we could only include 15 studies (Müller, Alley, Schoeppe, & Vandelanotte, 2016) – this is very little compared to what evidence base we have from developed countries where only about 20% of the world population lives. And when one looks into

these 15 studies it becomes apparent that the development of the interventions seems to be mainly informed by interventional mHealth research conducted in other regions (mostly Europe, America and Australia). This is not necessarily a problem because the majority of interventions were successful in improving physical activity and/or dietary behaviours – and this is what really counts in the end of the day.

However, there are two related notions that should be of interest to behavioural mHealth researchers: 1) Intervention developers seem to overemphasise the technology and its widespread use in the respective developing countries as the main factor to a successful intervention; 2) mHealth interventions seem to be developed and implemented in a sociocultural vacuum - the template for many mHealth interventions are mainly interventions from developed countries. What is currently lacking is a well-developed approach that would enable us to explore how to best design culturally-informed behavioural mHealth interventions. Such an approach is essential because we cannot assume that mHealth interventions developed in one culture can simply be translated into another culture without consulting the cultural context in which they should operate; this is especially important when the population and its culture is barely studied (Chib, van Velthoven, & Car, 2015). In the realm of behavioural mHealth it is necessary to examine the cultural context and how it shapes (health) behaviour, the interaction with mobile technology, and how user interfaces and intervention content is perceived (Burns, Montague, & Mohr, 2013). For example, individualism is a common characteristic of many developed countries, and in individualist cultures personal choice and freedom, self-actualisation and privacy are highly valued (Oyserman, Coon, & Kemmelmeier, 2002). These values are also reflected in the way behavioural mHealth interventions are designed: interventions are developed based on the assumption that participants own a mobile device which only they use; self-monitoring of behaviour leading to personal goal achievement is a common intervention element. In comparison, many developing countries have a collectivist culture in which the individual and his perceptions, thoughts and behaviours are strongly influenced by the communal environment. Arguably, in such societies sharing of mobile phones is not uncommon, and this has implications for how the mobile technology should be implemented in an mHealth intervention. In addition, it might be worthwhile to examine the acceptability of behaviour change techniques such as goal-setting and self-monitoring that are commonly applied in behavioural mHealth intervention, but for which the evidence base mainly comes from developed countries. With this, it is also necessary to properly examine how far our psychological knowledge and perspectives are valid in other cultures, and to also explore and unveil aspects that are relevant to different cultures (Segall, Lonner, & Berry, 1998). Integrating culture-specific insights related to the technology as intervention delivery modality and related to the behavioural intervention content when designing behavioural mHealth interventions can increase the acceptability of and engagement with these interventions leading to even stronger health behaviour change.

In sum, in addition to a person-based approach that is increasingly embraced by digital health researchers (Yardley, Morrison, Bradbury, & Muller, 2015) a culture-based approach needs to be developed to fruitfully examine individual as well as cultural characteristics of intervention users to inform the development of behavioural mHealth interventions.

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